Monograph 45

Ridership Impacts of Transit-Focused Development in California

Robert Cervero

NTrac
National Transit Access Center

November 1993

University of California at Berkeley

Ridership Impacts of Transit-Focused Development in California

Robert Cervero

Professor of City and Regional Planning
Co-Director, National Transit Access Center

With Research Assistance by Michael Carroll, Jason Munkres, and Jodi Ketelsen

Report to The California Department of Transportation and The University of California Transportation Center

University of California at Berkeley
Institute of Urban and Regional Development

Table of Contents

Chapter Five

Chapter Six

Chapter Seven

Chapter Eight

Tables

Table No.

Figures

Figure No.

Maps

Ridership Impacts of Transit-Focused Development in California

Executive Summary

1. Introduction

Billions of dollars have been and are being spent on urban rail transit in California, yet the last 20 years have seen the private automobile increase its market share of travel at the expense of public transportation. Between 1980 and 1990, for instance, transit's share of commute trips fell from 5.4 percent to 4.8 percent in greater Los Angeles and from 11.9 percent to 10.0 percent in the San Francisco Bay Area.

One possible strategy for reversing this trend would be to concentrate more housing and workplaces around rail stations — that is, put more of the ends of the commute trip, home and work, near transit. Besides increasing transit ridership, other secondary benefits might accrue: improved air quality (especially to the extent short park-and-ride trips are converted to walk-and-ride); higher revenues (not just from farebox returns but possible joint development programs like air rights leasing); inner-city redevelopment and increases in affordable housing; and infill development and more efficient urban form.

California has already made considerable headway in achieving transit-focused development. To date, for instance, the Bay Area Rapid Transit (BART) District has negotiated several joint development deals with private builders to construct mid-rise housing complexes on existing parking lots at the El Cerrito, Pleasant Hill, and Hayward stations. While traditionally viewed as a deterrent to development, over time parking lots can actually function as an asset since they represent large tracts of pre-assembled, singularly owned, and cleared land that is relatively cheap to build upon. Other factors working in favor of transit-focused development include the burgeoning need for affordable housing as well as the many incentives governments have available to promote transit-linked development, including tax-exempt financing, redevelopment powers, and zoning controls. However, many barriers also exist: tight credit, questionable market viability, NIMBY reactions to high densities, and exclusionary practices, like fiscal zoning, that keep out apartments.

This report examines evidence on the degree to which existing large-scale developments near rail stations in California have encouraged transit usage. Ridership patterns are studied for housing, office-workplace, and retail developments. In addition to quantifying the ridership impacts of transit-focused developments, the study also seeks to explain those factors which appear to most directly account for the travel choices of people living, working, and shopping near rail stations.

2. Evidence to Date

Several earlier studies explored similar questions. A 1991 survey of residents living in four large apartment complexes within one-third mile of different East Bay BART stations found that 38 percent regularly commuted by BART. More in-depth surveys were conducted in 1987 and 1989 on the ridership profiles of large-scale developments near Metrorail stations in the greater Washington, D.C., area. For residential projects, shares of work trips taken by rail ranged from 18 to 63 percent. Ridership was the highest for projects closest to Metrorail stations and among station-area residents headed to central Washington, D.C., for work. Downtown offices averaged work trip modal splits of around 50 percent, compared to less than 20 percent for suburban office projects near rail. For retail centers near Metrorail, location and time of trip were the most important determinant of mode choice —well over 50 percent of shop trips made to large downtown retail stores or made to other close-by malls during the midday were by Metrorail.

Another important earlier study on this topic was conducted in Toronto and Edmonton, Canada. For transit-focused development in these two cities, even higher rail modal splits were found than in Washington, D.C. Additionally, the catchment area that people would be willing to walk to a station was found to extend as far as 4,000 feet. Other research has shown that acceptable walking distances can be stretched considerably (perhaps as much as doubled) by creating pleasant, interesting urban spaces and corridors.

3. Study Methodology

In this study, surveys were conducted of developments near California rail stations that met these criteria: (1) maximum distance: sites had to lie within two-thirds of a mile from stations, and ideally within the more walkable distance of one-third mile; and (2) minimum size: the following thresholds had to be met — residential (75 dwelling units); office (10,000 square feet or 100 employees); and retail (400,000 square feet). Candidate sites were screened for the following five California rail systems: BART; CalTrain; and Santa Clara County Transit (SCCTA); Sacramento Transit (ST); and San Diego Transit (SDT). These systems represent a mix of rail technologies: BART— heavy rail; CalTrain —commuter rail; and SCCTA, ST, and SDT — light rail. In all, 27 residential projects located near 20 different rail stations were surveyed. Surveys were mailed to all households at these sites, eliciting data on "main" weekday trips made by persons 16 years and above. The response rate was 18.4 percent, providing data on over 2,500 trips among nearly 900 individuals.

For transit-focused offices, surveys were conducted at the workplace with the approval of office management. In all, data were compiled from 1,430 workers at 18 transit-focused offices in California, representing a 22.7 percent response rate. Lastly, pedestrian intercept surveys were carried out to gather travel data for shoppers and others at retail centers near BART stations, producing around 900 survey responses.

4. Transit-Focused Housing

The following results were found for the 27 surveyed residential sites.

- The average rail modal split for all trips was 15 percent, with significant variation. Rail shares as high as 79 percent and as low as 2.0 percent were found among residential projects. Housing around BART averaged the highest rail splits (26.8 percent), while housing around SCCTA averaged the lowest (6.7 percent). Overall, those residing near California rail stations are fairly auto-dependent — over 75 percent relied on a car, either as a driver or a passenger, for their primary trips.
- Rail captured 19 percent of work trips made by station-area residents, and in the case of BART, 33 percent. This is much higher than the three BART-served counties' rail modal split of 5 percent for work trips in 1990. It is also considerably higher than the 1990 average of 17.8 percent for all Bay Area residents living within one-half mile of a BART station. For each Bay Area city served by BART, residents living near rail stations were around five times as likely to commute by rail transit as the average resident-worker in the same city.
- The strongest predictors of whether station-area residents commuted by rail was whether their destination was near a rail station and whether they could park free at their destination. Other significant predictors were vehicle ownership levels and the availability of employer-paid transit allowances. If station-area residents work in San Francisco for an employer who charges for parking and they receive a transit voucher, there is over a 95 percent chance they will commute by BART. If the same conditions hold and they work in Oakland, the probability falls to 64 percent; and for most other BART-served destinations, the odds are in the 10 to 15 percent range. And if they work at a destination beyond normal walking distance from BART and receive free parking, there is only around a 2 percent chance they will commute by rail. Clearly, if transit-based housing is to produce meaningful mobility and environmental benefits, there must also be transit-focused employment centers.
- Many of those surveyed who previously lived elsewhere in the same metropolitan area, though not near a rail station, changed modes of travel once they moved close to rail— around 29 percent who usually drove alone to work at their previous residence now commute by rail. A majority of current rail users, however, previously rode rail or bus to work. Part of the high incidence of rail commuting among station-area residents, then, could be due to the fact that they have a high proclivity to patronize rail transit. Also, the decision to rent or buy a home near a rail station might have been influenced by a desire to commute to work by rail transit.

- As might be expected, the vast majority of those residing near rail accessed nearby stations by foot — around nine out of ten. Once they reached their exit station, around three-quarters walked to their destinations.
- Households near rail stations were smaller in size (average = 1.89 persons) and owned fewer vehicles (average = 1.53 cars or trucks) than other households in the respective metropolitan areas.

5. Transit-Focused Workplaces

The following results were found for the 18 surveyed offices and workplaces.

- The average rail modal split for work trips was 8.8 percent. For surveyed worksites near BART, rail's share was 17.1 percent, well above the Bay Area's rail work trip share of 5 percent. On average, those working near California rail stations were 2.7 times more likely to commute by rail than the average worker in the cities studied.
- The strongest predictors of whether station-area workers commuted by rail was whether they resided in a rail-served city, could park free at their workplaces, and had access to a private vehicle. Living in a BART-served city, for instance, increased the likelihood of station-area workers commuting by BART by 40 percentage points, all else equal. Free parking reduced the likelihood by around 20 percentage points. Rail commuting also increased with commute distance and the availability of a transit allowance (when combined with paid parking at the workplace). Overall, these findings are consistent with those for transit-based housing — both the origin and destination ends of the commute trip need to be in reasonably close proximity to a station for there to be high levels of rail travel. That is, transit-based workplaces require transit-based housing if rail travel is to seriously compete with the private automobile.
- Of station-area workers who previously worked at a location unserved by rail but within the same metropolitan area, only around 31 percent commuting by rail now used it before. From this, one can infer that working near a rail station raises the likelihood of commuting by rail by 30 or so percentage points, all else being equal.
- Working near rail was not a strong inducement to using rail for midday travel. Only 3 percent of midday trips made by station-area workers were by rail. The need to make midday trips, on the other hand, reduced the odds that station-area workers commuted by rail.
- Among station-area workers who commuted by rail, slightly more than 50 percent park-and-rode at the originating station. Around one out of five reached the station by foot. Once at their destination station, over 85 percent walked to their nearby workplace.

6. Transit-Focused Retail Centers

The following results were obtained for the three large Bay Area shopping complexes located within a quarter-mile of a BART station. SFCentre is located in the heart of downtown San Francisco's retail district where parking is expensive and transit services are superior to anywhere else in the region. Both El Cerrito Plaza and Bayfair shopping center are large enclosed complexes in the East Bay, surrounded by free parking.

- For all three shopping centers combined, 15 percent of those surveyed arrived at the center by BART. The two suburban shopping malls with plentiful parking had lower rail shares —especially El Cerrito, where only 6.6 percent of shoppers and others surveyed arrived by BART.
- SFCentre's relatively high share of BART users partly reflects its larger retail marketshed —around 14 percent traveled over 20 miles to get there. However, over one-third also traveled less than a mile to SFCentre — typically downtown workers and tourists.
- Shoppers who arrived by rail tended to be women, youths, and ethnic minorities.

7. Influences of the Built Environment

The relationships between transit ridership and the site and neighborhood characteristics of the 27 residential and 18 workplaces were also explored. The following was found.

- Rail's modal share fell linearly with distance from the station for the surveyed housing projects —on average, by about 0.85 percentage point for every 100-foot increase in walking distance.
- For offices, the ridership gradient followed an exponential decay function. For non-BART sites, only offices within 500 feet of a station had as much as 15 percent of their workers commuting by rail; beyond 500 feet, no more than 10 percent of workers took rail to work.
- In general, ridership gradients for California transit-focused projects were flatter and lower than those found in previous studies for Washington, D.C., Toronto, and Edmonton. This is likely attributable to the greater abundance of park-and-ride facilities at California stations, differences in urban form, and the higher degree of workplace primacy (i.e., larger downtowns) in these other cities.
- Among land-use variables studied, ridership for transit-based housing projects was most strongly related to neighborhood density and proximity. Mixed land uses and various indicators of "walking quality" were not significant predictors of transit modals splits among residential sites. Thus, within a one-half mile or so radius of a station, land uses or features of the built environment matter very little — as long as residences are near stations, the characteristics of the immediate surroundings are of minor importance, barring no serious problems like blight or high crime rates.

- For office developments, proximity and areawide densities were the two dominant site-related factors influencing rail usage. For every additional 100 employees per acre, rail ridership rose 2.2 percent. Mixed uses and measures of environmental and walking quality were not significant predictors of the share of station-area workers who commuted by rail.
- Overall, it is the "clustering" (i.e., close proximity and higher densities) of residences and workplaces near rail stations that has the biggest influence on travel behavior among all land-use factors. Factors like levels of mixed uses or quality of walking environment have a negligible influence. As long as development is geographically close and oriented toward a rail station, reasonable shares of residents and workers will travel by rail. To the degree both ends of trips are clustered around a rail station, the odds of traveling by rail transit increase sharply.

8. Conclusions

The principle conclusion of this research is that if transit-focused development is to reap significant mobility and environmental benefits, then most kinds of trip origins and destinations must be clustered around rail stations. Having transit-based housing does little good if most job growth occurs outside of CBDs or far removed from rail stations— such as in suburban office parks and highway corridors. Likewise, rail-served shopping centers will attract relatively few transit users if most residences and workplaces are not oriented to transit. In short, a variety of urban activities need to be concentrated near transit facilities if significant shares of trips are to be won over to transit, especially given the trend towards decentralization. We can conclude, then, that for rail transit to work effectively, metropolitan areas need a multi-centered urban form that is fed by an efficient transit system —that is, they need to be more like some of the world's most successful transit metropolises, such as Stockholm and Toronto. In addition to clustered development around rail stations, other complementary policies and programs need to be in place — such as universal parking charges and employer-paid transit allowances. Together, transit-focused land-use measures and transportation demand management (TDM) programs are a powerful combination for inducing modal shifts to transit.

The ability of transit-focused development, by itself, to produce significant regional mobility is clearly limited. For example, only 8.9 percent of residents from the three BART-served counties lived within one-half mile of a BART station in 1990. Based on 1990 census statistics, only 17.8 percent of these station-area residents commuted by rail transit. This means that only 1.6 percent of all commute trips by residents of the three BART-served counties were by station-area rail users. Doubling or even tripling the amount of transit-based housing would clearly have a modest impact on regional traffic and environmental conditions, in and of itself. However, were these efforts complemented by more transit-based workplaces and restraints on private automobile usage (mainly in the form of mandatory parking charges and bridge tolls), the mobility and environmental impacts of concentrated development around BART stations would likely be significant. Better pricing and better urban design, along with better regional planning, would go a long way toward producing built forms that begin to attract substantial numbers of Americans to transit and other alternatives to the drive-alone automobile.

Acknowledgements

This research was supported by a grant from the University Transit Research Program, California Department of Transportation. We thank our sponsors for their generous support.

Robert Cervero, Professor of City and Regional Planning and Co-Director of the National Transit Access Center (NTRAC), was the Principle Investigator of the project and directed all phases of the research. He authored Chapters One through Four and Eight of the report, and co-authored the other chapters. Michael Carroll, Jason Munkres, and Jodi Ketelsen, all graduate students in the Department of City and Regional Planning at the University of California at Berkeley, were Research Assistants on the project. Besides assisting with data collection and entry, Michael contributed to Chapter Five, Jason to Chapter Six, and Jodi to Chapter Seven of the report.

We wish to thank the many apartment managers, employers, and other individuals who assisted us in our data collection efforts. Without their help, this research would not have been possible. We also thank staff from the Institute of Urban and Regional Development for all their assistance in seeing this report through to production, particularly Barbara Hadenfeldt for her editorial assistance and David Van Arnam for going well beyond the call of duty in assisting with word-processing and type-editing. Jane Stertzinger did a splendid job in preparing maps for the report. Also, our thanks to Michael Bernick, Co-Director of NTRAC, for his continuing encouragement to probe the boundaries of what's possible with transit-based housing.

Our sincere thanks goes to all of these individuals and organizations. The views expressed are ours and not necessarily those of our sponsors or any one else assisting with this project. We alone are responsible for any errors or misinterpretations that may be contained in this report.

Chapter One

Transit-Focused Development in California: Rationales, Issues, and Opportunities

1. Introduction

Over $6 billion has been invested in urban rail transit in California over the past 20 years, and another $7.5 billion is committed to projects in various stages of planning and development. Metropolitan Los Angeles-Long Beach, Sacramento, San Diego, and San Francisco-Oakland-San Jose have built rail transit systems in recent decades not only in hopes of enhancing regional mobility but also to reduce air pollution and fuel consumption and to guide urban growth.

Transit, of course, only produces mobility and environmental benefits if people switch from driving cars to riding trains and buses. Many factors, however, are eroding transit's ridership base —rapid suburbanization in particular, much of which is focused on highway corridors. Nationwide, transit ridership fell from 6.4 percent of all commute trips in 1980 to 5.3 percent in 1990 (Pisarski, 1992). Among suburban residents commuting to work, moreover, transit's market share fell by 2.1 percentage points during the 1980s in the 25 largest U.S. metropolitan areas (Cervero, 1993b). While transit trips rose in absolute numbers in California between 1980 and 1990 (one of the few states where this was the case), transit's share of commute trips fell in all metropolitan areas: greater Los Angeles —5.4 percent to 4.8 percent; San Francisco Bay Area— 11.9 percent to 10.0 percent; San Diego —3.7 percent to 3.6 percent; and Sacramento—3.7 percent to 2.5 percent.

Given the billions of dollars already invested in urban rail transit in California and the billions more currently in the pipeline, these trends are worrisome. California policymakers must respond creatively to reverse transit's downward decline. One possibility is to create attractive living and working environments around rail stations that will lure more and more households and firms to locate nearby. Whether clustered development around transit stops means substantially more Californians will patronize mass transit remains unclear, however. Can transit-focused development help counter the many factors, such as rapid suburbanization and free parking, that are attracting increasing numbers of Californians to their private automobiles? Will it have any meaningful effect on transit ridership, regional mobility, and environmental quality? Do the characteristics of the built environment around suburban transit stations, such as density and degrees of land-use mixtures, make any difference? This report aims to shed light on these and other policy-relevant questions about transit-focused development in California.

The primary purpose of this research is to document the ridership impacts of existing residential, office, and retail developments near the stations of five rail transit systems in California—

Bay Area Rapid Transit (BART), Santa Clara Light Rail Transit, Peninsula CalTrain, Sacramento Regional Transit, and San Diego Trolley. Among California's urban rail systems, these have been in operation the longest and thus provide a context for studying the ridership impacts of transit-based development around more mature station environments.[1] Moreover, they span a range of rail transit technologies —heavy rail (BART), commuter rail (Peninsula CalTrain), and light rail (Santa Clara, Sacramento, and San Diego).[2] The report goes well beyond describing ridership impacts, however. It also examines how ridership varies among different sociodemographic and trip-making submarkets, and analyzes factors that influence rail users' modes of access. Also, the effects of the built environment— such as density, land-use mixtures, and levels of amenity— on the ridership characteristics of transit-focused development are studied.

2. Transit-Focused Development in California

Interest in clustering housing and commercial development around rail transit stations has gained momentum in recent years. Rail transit agencies like BART and San Diego's Metropolitan Transit Development Board (MTDB) see an opportunity to jointly develop land holdings around stations, including park-and-ride lots, in association with private real-estate developers, hopefully earning lease income and generating new patronage in the process. To date, BART has negotiated several joint development deals with developers to build mid-rise housing complexes on existing parking lots at the El Cerrito, Pleasant Hill, and Hayward BART stations. Rising land values and pressures for affordable housing have prompted BART to seriously consider converting parts of its vast inventory of park-and-ride lots to mid-rise housing. These projects may eventually lead to mini-communities mushrooming around dozens of BART stations, as was envisaged when BART was originally conceived over 40 years ago.

Plenty of building activity can also be found around other rail stations in California as well. In Mountain View, several multi-family projects near the CalTrain station are being built, including an apartment complex with 700 units at the Old Mill Shopping Center. Santa Clara County's light-rail stations have attracted several "trandominium" housing projects that rely on rail proximity as an important marketing tool; demand is so high for new units at two unfinished San Jose trandominium projects that the developers have had to resort to waiting lists. As part of Santa Clara County's Housing Initiative Program, plans are underway to eventually build over 13,700 units of moderate-density housing (at 12 to 40 dwelling units per acre) near light rail stations. San Diego has already seen a flurry of recent apartment construction along the new El Cajon extension, including more than 500 attractive apartment units recently built near the Amaya station.

The growing popularity of traditional neighborhood designs (TNDs) and transit-oriented development (TODs) has spawned particular interest in rail-based housing and mixed-use projects, especially in California. These design motifs aim to reduce auto-dependency by creating attractive environments for walking and using transit. The TNDs of architects Andres Duany and Elizabeth Plater-Zybeck borrow the successful elements of traditional turn-of-the-century transit communities: a commercial core within walking distance of a majority of residents; a well-connected (typically grid) street pattern; narrow streets with curbside parking; mixed uses; and varying densities of housing (Lerner-Lam et al., 1992; Beimborn and Rabinowitz, 1991).

In California, Sacramento County has most aggressively pursued transit-oriented developments (TODs), which have become the cornerstone of the county's updated General Plan. The Plan expressly aims to "promote strong linkages between transit and land use by facilitating the development of higher residential densities and commercial intensities at transit stops and along transit corridors." One master-planned new town, Laguna West, is being built as a TOD, incorporating a feeder bus line which might one day be replaced by the extension of Sacramento's light rail system. Laguna West's architect Peter Calthorpe designed the community so that over 80 percent of residents would be within a one-quarter-mile walking distance of a transit stop.

Developers, it should be stressed, are not being coerced into transit-based developments. All are willing partners, seeing an opportunity to fill a new market niche— providing moderate-priced housing with superb regional accessibility. In addition to transit agencies and developers, local governments are an important player in promoting transit-focused development. The cities of Hayward, Union City, El Cerrito, and Pleasant Hill have recently formed redevelopment districts around BART stations for this very purpose. El Cerrito's redevelopment authority has used tax-exempt financing and subsidies for below-market housing to leverage private investment in three major multi-family projects near the El Cerrito del Norte BART station. Sacramento's updated General Plan has targeted 13 LRT station areas for introducing an array of development incentives, including: higher allowable residential densities, lower minimum parking requirements, density bonuses, tax-increment financing, and industrial development bonds. Other jurisdictions are following suit. A recent survey found that 10 of the 36 northern California jurisdictions with rail transit stations have undertaken major planning activities to attract development around stations, and several have made transit-based development a primary planning goal (Bernick et al., 1993).

In recent years, important state and federal laws have been passed that will reinforce and likely heighten interest in transit-based development. The 1991 national surface transportation act (ISTEA) and federal and state air quality regulations stress the importance of increasing transit ridership in major urban centers. ISTEA requires state departments of transportation and metropolitan planning organizations (MPOs) to assess transportation and land use decisions in relation to one another. The recent Americans with Disabilities Act (ADA), moreover, will likely work toward closer physical integration of transit facilities and surrounding communities so as to guarantee everyone equal access to rail transit facilities.

California has emerged as a national leader in legislating and promoting stronger linkages between transportation and urban development. As part of the legislative package for Proposition 111 (which increased the state gas tax), California recently enacted AB471 that requires all cities and urban counties to prepare a Congestion Management Plan. A key component of this plan is a requirement that local land-use decisions be assessed in terms of how they will affect regional transportation systems. California's stringent air quality requirements have also pressured severe non-attainment areas like Los Angeles County to more closely integrate land use and transportation planning. Indeed, one of the principal justifications for Los Angeles's new rail system and BART extensions has been to reduce mobile sources of air pollution. Clearly, these investments will only impact air quality if they induce significant numbers of motorists to switch over to transit riding. This will depend, in part, on creating denser, more mixed-use nodes of development around existing rail stations.

3. Expected Benefits of Transit-Focused Development

The primary benefit of having more of California's urban development focused around rail transit stations is that transit usage would likely increase as a result. Deciphering "how much" is the principal focus of this research.

The spin-off, or secondary, benefits from converting more urban travel to public transit have particular policy appeal. Among the likely secondary benefits are:

Improved mobility and environmental conditions: Ridership increases could relieve traffic congestion along roads paralleling rail transit lines and reduce automotive tailpipe emissions.

Placing more housing and jobs near rail stations could further reduce air pollution by converting some park-and-ride and kiss-and-ride trips to walk-and-ride. Currently, an estimated 80 percent of suburban Bay Area residents who ride BART access stations via private automobile (Sedway and Associates, 1989). These suburban transit users do little to improve air quality and conserve fuel, since emission and fuel consumption rates are relatively high for short automobile trips due to cold starts and hot evaporative soaks. For a five-mile journey, the typical distance of a park-and-ride trip to a rail station, around 85 percent of hydrocarbon emissions are due to cold starts and hot soaks (Cameron, 1991). All of California's large cities currently exceed federal and state clean air standards for ozone and carbon monoxide. To the degree transit-based development induces more walk access, it could yield important air quality benefits.

Increased transit revenue yields: Higher ridership would increase farebox income, thus reducing the reliance of transit agencies on operating subsidies. Income can also be generated from land and air rights leases, station connection fees, benefit assessments, and other forms of value capture (Cervero et al., 1992). And to the extent that benefits of being near regional rail stations are capitalized into higher land values and rents, governments should also receive more property tax and value-added income.

Increased stock of affordable housing: All California metropolises suffer from a shortage of affordable housing, forcing many moderate-income people, younger families, and first-time home-buyers to reside on the exurban fringe. Should the supply of affordable housing available to Bay Area workers be largely limited to the Central Valley when there are vast amounts of open, developable land around some BART stations? Increases in allowable residential densities around rail stations could lower unit housing costs in addition to reducing transportation costs. With less dependency on car transport, some families might no longer need to own a second car, for example.

Other social benefits: In addition to responding to California's most serious housing dilemma —the lack of affordable shelter— transit-based development could be a catalyst to redeveloping depressed and marginal inner-city neighborhoods. An aggressive program of transit-oriented development, in combination with other social programs like job training, could encourage more private investment in America's urban centers. Transit-focused development would also provide more live-travel options for older Americans and empty-nesters, disabled persons, and other transit-needy groups. Rather than living in an auto-oriented suburb, more Americans might opt to reside in a transit-oriented urban setting if given a choice.

More efficient urban form: Transit-focused development would also promote infilling and help to preserve natural resources, including open space and agricultural land. Physical and social infrastructure costs could also be contained to the extent that urbanization becomes more inward-focused and less dispersed.

In summary, transit-focused development offers an opportunity to help redress some of the state's and the nation's most pressing urban and transportation problems, including air pollution, lack of affordable housing, traffic congestion, inner-city distress, physical barriers to mobility, and costly sprawl. These secondary benefits will be limited, of course, by the degree to which residents, workers, and tenants of station-area developments actually patronize transit— the primary benefit of transit-focused growth.

4. Opportunities and Barriers

Opportunities

As discussed previously, recent state and federal initiatives, like the clean air programs, have created a legislative environment that is conducive to transit-oriented development. Market trends such as overbuilt commercial space and the need for more affordable housing have also favored putting housing near rail stations, which was referred to at a recent Urban Land Institute conference as the "niche real estate market of the 1990s." Transit agencies and land developers have both moved up the learning curve based on experiences with commercial joint development during the 1980s, which should ease the negotiating process for housing joint development schemes now and in the future.

Another set of inducements to transit-focused development are the many incentives governments have at their disposal, including tax-exempt financing, zoning variances, redevelopment powers, density bonuses, impact fee credits, and reduced parking requirements. It is government's ability to assemble land, such as through land banking, eminent domain, or redevelopment takings, and thus help write down costs, that is most appealing to prospective real estate developers (Bernick et al., 1993). For many transit agencies, surface parking lots that encircle stations are their biggest development asset. Parking lots represent large tracts of pre-assembled, cleared land that is relatively cheap to build upon. Importantly, developers do not have to bear the risk of negotiating land purchases among multiple property owners, any one of whom can hold out, thereby dooming a project. To date, BART has negotiated with developers to build apartments on existing park-and-ride lots at three stations in response to rising land values, local interest in revitalizing station areas, and pressures to increase income through land leases.

In many ways, the conversion of park-and-ride lots to housing and other uses represents a *de facto* form of land banking. One of the reasons why so much urban growth has clustered around rail transit stations in cities like Toronto and Stockholm is that local governments were able to acqire land over and beyond what was necessary to build the system. In Toronto, the metropolitan government used eminent domain rights to acquire some 18 extra city blocks along the Yonge Street subway corridor, land that was later leased or sold to residential and commercial developers. In the U.S., state and federal laws prohibit excess land acquisitions — public agencies can exercise eminent domain powers to condemn land that is directly related to the provision of a public facility. As station areas mature, however, transit agencies may be in a position to build upon surface parking lots, achieving results similar to land banking over time. The opportunity for reusing park-and-ride facilities is greatest at terminal stations that are slated to become intermediate stations as a result of line extensions. Such was the case at the Ballston Station in Arlington, Virginia, after Washington Metrorail's Orange Line was extended into Fairfax County. When a major bus transfer facility was relocated to the new terminus, the Washington Metropolitan Area Transit Authority (WMATA) negotiated a long-term lease with a developer who built a 28-story office-residential-retail complex on the land that was freed up.

Barriers

Working against these opportunities for transit-based development are a number of serious obstacles. Some are economic, some are political, and some are structural in nature.

Among the economic barriers are questionable market viability, tight credit, and potentially high development costs associated with transit-oriented development. A recent survey by the Building Industry Association of Northern California found that 82 percent of Bay Area residents (excluding San Francisco residents) preferred a single-family house to any other housing type. Some developers also fear transit's presence will reduce the marketability of their projects, especially along lines that connect to poor inner-city neighorhoods. One developer of a mixed-use project near the trolley line in San Diego remarked at a recent American Public Transit Association (APTA) conference that he would not lease to prospective tenants who were seeking space expressly to be near a trolley stop because of potential security and image problems. The clear inference was that the developer did not want a tenant whose clients relied heavily on transit, typically inner-city residents. Class conflicts are no doubt at the subsurface of some transit-related development decisions.

Institutional inertia also stands in the way of transit-focused development. Because of the economy, the softness of most real estate markets, and the bankruptcy caused by the savings and loans crisis, many of today's lending institutions are hesitant to provide construction or permanent financing for large-scale developments, like transit-based housing, that have no proven track record. Banks, moreover, typically resist efforts to provide below-standard parking, even when superb quality transit services are available. Developers themselves are today more risk-averse, no longer able to take advantage of the real estate tax shelters of the 1980s.

Even state institutions have thwarted efforts to build transit-oriented communities: in Virginia, the state department of transportation designated all roads in a Loudon County neotraditional development as private passageways (and thus not eligible for state funding or maintenance) on the grounds that the project's strong pedestrian orientation and resulting narrow road rights-of-way were "substandard," which would make the state liable in the event of road accidents.

Higher-density development also raises construction costs, especially when structured parking is required. And developments near rail transit stations sometimes require additional outlays for security and liability insurance, further raising costs. Such add-ons work against the goal of providing more affordable housing near rail transit. While governments can use tax-exempt financing and impact fee waivers to help offset these higher costs, some developers are reluctant to risk large amounts of capital without the kinds of long-term guarantees that many governments are unable or unwilling to give.

Among the political barriers to transit-based development is neighborhood resistance to higher density construction and fiscal zoning. For instance, residents around BART's Rockridge, Concord, Orinda, and North Berkeley stations have over the years pressured their respective city councils to downzone their neighborhoods to prevent any intensification. Most viewed new prospective residential and commercial development as physically intrusive and as a threat to property values and neighborhood stability. Many local governments have also tended to shun the construction of apartments because of the common view that they demand high levels of public service which are not covered by the property taxes they generate.

Several structural barriers have also limited the amount of residential and commercial construction near California rail stations. Many rail stations are in the medians of freeways (e.g., BART's Concord line) or situated along former freight lines that traverse industrial belts with modest development potential (e.g., San Diego Trolley's South line). Such areas are often unappealling for housing development and bereft of neighborhood character and urban amenities. Lastly, the United States lacks prototypes of successful transit-based suburban developments that developers could emulate.

Public Policy

To the extent that transit-based developments provide demonstrable public benefits, an important role for public policy will be to capitalize on the opportunities for such projects and to attenuate the barriers. For example, city fees could be lowered for transit-focused developments. The Contra Costa County Redevelopment District was formed to help finance local infrastructure around the Pleasant Hill BART station, thus relieving the private sector of some development fees. The city of San Jose recently wrote down the land costs and loaned money for the underground parking structure for Ryland Mews, a 130-unit condominium project now under construction near the Japantown Light Rail station.

Neigborhood and NIMBY opposition to station-area development can be quelled by involving local residents in the decision-making process early on and through negotiations that promise neighborhoods something in return for accepting higher density housing. A *quid pro quo* might be to match infilling and densification with additional amenities, such as the enlargement of civic spaces or improved public landscaping. Community leaders might also be introduced to successful transit-based developments to help allay their fears. For example, an affordable Bay Area housing project built by Bridge Housing Corporation won neighborhood approval after the developer gave local residents an on-site tour of a similar project that was attractive and well-maintained.

5. Report Organization

The remainder of this report examines the degree to which existing large-scale developments near rail stations in California have encouraged high levels of transit usage. In addition to quantifying the transit ridership characteristic of transit-focused housing, office, and retail projects, the following analyses also seek to explain those factors which appear to most directly account for ridership patterns.

The next chapter summarizes what we currently know about the ridership impacts of transit-focused development, drawing upon research findings from earlier studies done in the greater Washington, D.C., area, Canada, and California. Chapter Three outlines the methodology and analytic models used in this research. Attention is given to the describing survey instruments and the sampling frame used in the research.

Chapters Four through Six present the empirical findings on the ridership characteristics of different land uses around California rail stations. Each chapter similarly characterizes the socio-economic and trip-making profiles of station-area developments. Trips are defined with regard to purpose, mode, time-of-day, length, travel time, and origin-destination pattern. Models that explain variation in modal splits and other trip-making behavior are also presented. Analyses are carried out on how ridership varies with distance from rail stations and on how customers access stations. Chapter Four presents these materials for the residents of 27 transit-based housing projects surveyed in California. Chapter Five complements this with an analysis of transit-based office projects. And Chapter Six presents some evidence on transit usage by shoppers in the Bay Area.

Chapter Seven focuses on the link between the land use and urban design characteristics of residential and office sites and levels of transit usage. Models are presented which explain how modal splits vary by such factors as density, levels of land-use mixtures, origin-destination trip patterns, and neighborhood walking characteristics.

Chapter Eight concludes the report with a summary of key research findings, policy recommendations, and suggestions for future research. An extensive appendix (consisting of the survey instrument and more detailed statistical findings) and bibliography can be found at the end of the report.

Notes

[1]Transit operations commenced as follows: BART —1972-73; Santa Clara LRT — 1987; Peninsula CalTrain —around 1910; San Diego Transit —1981; and Sacramento Regional Transit —1987. Although new rail services have been introduced in Los Angeles County over the past few years, transit-based developments were not studied there since the system is in its infancy and, outside of downtown Long Beach and Los Angeles, there are currently few large-scale developments within walking development of the Blue Line stations. San Francisco Muni's LRT was not included in this analysis since San Francisco is highly urbanized and built-up and averages comparatively high transit ridership levels. Since Muni's operating environment is more similar to many large eastcoast cities than to most of California, the relationship between Muni's ridership and nearby development was not examined in this work.

[2]Only developments around the stations of intrametropolitan rail systems were studied. inter-city passenger rail systems, such as Amtrak services between Los Angeles and San Diego or between Oakland and Sacramento, were not included in the study.

Chapter Two

Ridership Impacts of Transit-Focused Development: Evidence to Date

1. Introduction

To date, several studies have been conducted which examine the transit ridership characteristics of housing and commercial projects located near rail transit stations. This chapter summarizes the findings of these earlier studies, setting a benchmark on what we presently know. Empirical findings from the San Francisco Bay Area, Washington, D.C., area, and several Canadian cities are reviewed. The literature on two other related subjects is also briefly summarized: how far pedestrians will walk to stations, and the effects of land-use environments on transit usage.

2. Ridership by Proximity in the San Francisco Bay Area

So far, only informal surveys have been carried out on the ridership profiles of residents who live near BART stations. A 1991 study (Bernick and Carroll) interviewed residents living in four large apartment projects within one-third mile of four different East Bay BART stations: Treat Commons (Pleasant Hill station), the Verandas (Union City), Mission Wells (Fremont), and the Foothills (South Hayward). Densities in these projects ranged from 30 to 50 dwelling units per acre. In all, 63 of the 167 residents surveyed, or about 38 percent, indicated they used BART regularly for weekday commute trips.[1] This is much higher than the 9.5 percent transit modal split for commute trips made by the Bay Area work force in 1990 (Metropolitan Transportation Commission, 1992).

The 1991 survey found little relationship between distance to the station and transit modal splits for housing within the one-third-mile range. At Treat Commons (1,800 feet from the station), 40.5 percent of residents commuted regularly by BART. For the other projects, BART modal splits were: Verandas (700 feet away) —41.1 percent; Foothills (450 feet away)— 42 percent; and Mission Wells (1,200 feet away) —27.6 percent.[2] This analysis also found that not only did residential location influence transit ridership, but the rail system also influenced residential location: 44 to 62 percent of people surveyed cited BART as a "main" or "major" factor in choosing their residence.

Another earlier informal survey conducted in 1989 found a similar transit capture rate for housing near BART stations. Conducted by Sedway and Associates (1989), the survey of residents who lived close to three suburban stations on the Concord line (Concord, Pleasant Hill, and Walnut Creek) found that 35 to 40 percent used public transportation. This survey asked only if the residents used BART and did not consider frequency or trip purpose.

3. Ridership by Proximity in the Washington, D.C., Metropolitan Area

One of the most comprehensive analyses of rail ridership for developments near urban rail stations was conducted in the Washington, D.C., area in 1987 and 1989 by JHK & Associates. Four types of nearby land uses were examined: residences, offices, retail, and hotels. Like this study, only large-scale projects (e.g., residential buildings with 75 or more dwelling units) within approximately one-third mile of a station were included in the studies.

Residential Projects

The 1987 residential survey examined ridership at eight multifamily projects, some in downtown Washington, D.C., others in the suburbs. All projects had at least 75 units and ranged from 300 to 3,800 feet away from a station.

The 1987 results for residential projects are summarized in Table 2.1. Shares of work trips taken by rail ranged from 18 to 63 percent. Transit modal shares generally fell off gradually with distance from stations. For The Consulate complex, closest to any station (300 feet from the Van Ness-UDC station), 63 percent of residents commuted via rail. At the farthest development, Connecticut Heights, at 3,800 feet from the same station, 24 percent rode Metrorail to work. The close-in suburban Crystal City station was a notable exception to this pattern: rail ridership was higher at Crystal Plaza Apartments, 1,000 feet from the station, than at Crystal Square Apartments (which is home to a generally older population), only 500 feet from the station. From these data, the authors calculate that the share of trips by rail and bus transit declines by approximately 0.65 percent for every 100-foot increase in distance of a residential site from a Metrorail station portal.

Table 2.1

Modal Splits for Residential Developments Near Metrorail Stations, Washington, D.C., Area, 1987

Metrorail Station	Project	Distance to Station	% Rail	% Auto	% Other[1]
Rosslyn	River Place North	1,000 feet	45.3	41.5	13.3
	River Place South	1,500 feet	40.0	60.0	0.0
	Prospect House	2,200 feet	18.2	81.9	0.0
Crystal City	Crystal Square Apts.	500 feet	36.3	48.8	14.9
	Crystal Plaza Apts.	1,000 feet	44.0	45.0	11.0
Van Ness-UDC	The Consulate	300 feet	63.0	32.6	4.4
	Connecticut Heights	3,800 feet	24.0	56.0	20.0
Silver Spring	Twin Towers	900 feet	36.4	52.3	11.4
	Georgian Towers	1,400 feet	34.7	43.1	0.8

[1]"Other" consists of the bus, walking, and other forms of access.

Source: JHK & Associates (1987)

The 1987 survey was followed by a similar one two years later, carried out at ten different residential sites near five stations.[3] A similarly high transit modal share was found in the 1989 survey, ranging from 30 to 74 percent of commute trips. Transit usage varied considerably, however, depending on trip destination. For instance, in the case of the 507-unit Randolph Towers complex in Arlington, Virginia, which lies 500 feet from the Ballston Station portal, 69 percent of residents commuted via Metrorail. If they worked in Washington, D.C., the modal share was 88 percent. Among those working in nearby suburban Fairfax County, 33 percent rode Metrorail; among those working in Montgomery County, Maryland, 20 percent took rail to work.

Office Projects

The 1987 JHK survey of people working in offices near Metrorail stations revealed two clear patterns: ridership was much higher at downtown than at suburban sites; and, as in the residential survey, ridership fell off steadily as distance from offices to stations increased.

As shown in Table 2.2, nearly 50 percent of those working in downtown office buildings within 1,000 feet of the Metro Center or Farragut West Metrorail stations commuted via Metrorail, compared to 16 to 19 percent of workers at buildings at comparable distances from the suburban

Table 2.2

Modal Splits for Office Developments Near Metrorail Stations, Washington, D.C., Area, 1987

Metrorail Station	Project	Distance to Station	% Rail	% Auto	% Other[1]
Metro Center & Farragut West	International Square	200 feet	48.9	42.4	8.8
	NCPC Building	500 feet	46.6	36.5	16.8
	Olmsted Building	700 feet	43.5	45.4	11.4
	McKee Building	900 feet	50.5	32.5	17.0
	Realtor's Building	1,200 feet	45.6	28.3	26.1
	Am. Inst. of Architects	2,800 feet	27.4	55.9	16.7
Rosslyn	1300 N. 17th Street	800 feet	19.2	80.0	1.5
	AM Building	1,000 feet	24.3	73.4	1.6
	Air Force Assoc.	2,200 feet	13.3	85.3	1.5
Crystal City	Crystal Mall 1	200 feet	16.3	81.3	2.4
	Crystal Square 2	1,000 feet	17.4	77.2	5.5
	2711 Jeff-Davis	2,500 feet	5.4	90.2	5.0
Van Ness - UDC	Van Ness Station	100 feet	21.1	72.8	5.2
	Intelsat	300 feet	27.9	68.4	3.8
Silver Spring	Twin Towers	900 feet	36.4	52.3	11.4
	Georgian Towers	1,400 feet	34.7	43.1	0.8

[1]"Other" consists of the bus, walking, and other forms of access.

Source: JHK & Associates (1987)

Crystal City or Silver Spring stations. The researchers found that for downtown offices, transit ridership fell by 0.76 percent for each 100-foot increase in distance from a Metrorail portal, and for offices, 0.74 percent for each 100 feet.

The 1989 follow-up survey by JHK largely confirmed these 1987 findings. Place of residence was shown to be a particularly important explainer of whether office workers near Metrorail stations patronized transit. In the case of the Silver Spring Metro Center, a 150,000-square-foot office tower 200 feet from the Metrorail portal, 52 percent of workers residing in Washington, D.C., rode transit to work; among workers living in surrounding Mongtomery County, however, Metrorail was used by only 10 percent.

Retail Projects

The results of the 1987 and 1989 JHK retail surveys paralleled those of the office surveys; outside of downtown Washington, D.C., rail ridership among shoppers decreased sharply. In 1987, at the Hecht Company flagship store located near the downtown Metro Center station, 34 percent of surveyed customers had arrived via Metrorail, compared to only 1.1 percent at the Hecht Company store several blocks (1,100 feet) from the Silver Spring Metrorail station. The 1989 survey did find a surprisingly high transit modal split at The Underground shopping complex at the Crystal City Metrorail station in Alexandria, Virginia (just over 40 percent).[4] Transit mode share varied considerably, however, depending on time of day, from a peak of over 50 percent of midday shoppers surveyed to approximately 20 percent of evening customers. Numerous downtown Washington, D.C., workers, especially government employees with jobs near the Federal Triangle, ride Metrorail to The Underground for lunch, usually a 5- to 8-minute train ride away.

Washington Metrorail Survey Summary

JHK and Associates (1987, p. 1) concluded that "the most significant factors affecting the percent of trips by transit are: (1) the location of the site within the urban area and on the Metrorail system; and (2) the proximity of the building to a Metrorail station entrance." The origin-destination patterns of trips were also found to be crucial— "poor transit accessibility at either end of the trip results in poor transit ridership between those pairs" (p. 1).

4. Ridership by Proximity in Edmonton and Toronto, Canada

A second major earlier study on transit ridership by station proximity focused on two Canadian systems —the Toronto subway system and the Edmonton light rail system. The study, summarized in Stringham (1982), examined variation in rail modal splits as a function of distance to stations and modes of access for over 2,000 people either living or working near two suburban stations in each city.

The survey found that within a radial distance of 3,000 feet from a station, rail transit modal splits ranged from 30 to 60 percent of all work and school trips[5] The author estimated the "impact zone" (the area within which people walk to the station in significant numbers) to extend perhaps as far as 4,000 feet from a station. As in the Washington, D.C., study, the transit modal split of high-density residential development was about 30 percent higher than low-density projects at an equivalent distance from a station.

Also consistent with the Washington, D.C., study, Stringham's work found the transit modal split for offices located near suburban rail stations to be considerably lower than that of residences near the same stations, perhaps reflecting the availability of plentiful parking at the suburban businesses surveyed.

The Stringham study gives particular emphasis to how modes of access vary with distance from a station. The author found that well over 90 percent of rail users whose origin or destination was within 1,500 feet of a station walked to the station. At a distance of around 3,200 feet, bus transit eclipsed walking as the predominant mode of access. At 3,700, virtually no residents or workers walked to the station; around 15 percent reached the station by car and the remainder arrived by bus.

5. Other Work on Pedestrian Access

Untermann (1984) has conducted the most in-depth work to date on Americans' walking behavior. His research shows that most people are willing to walk 500 feet, 40 percent will walk 1,000 feet, and only 10 percent will walk half a mile. These figures do not specify purpose of the walk trip, however; for more crucial trips, such as to work, the Stringham study suggests that acceptable walking radii might be farther. Additionally, Untermann and others have shown that acceptable walking distances can be stretched considerably (perhaps as much as doubled) by creating pleasant, interesting urban spaces and corridors. This is perhaps reflected by the irony that many Americans will go to great lengths to find a parking spot close to the entrance of a shopping mall, but have no problem walking one or two miles once inside the mall. Average walking distances, moreover, are large in urban centers —60 percent of walk trips in downtown Boston are over one-quarter mile, and the average walking distance in Manhattan is one-third mile (Fruin, 1992).

Untermann contends a ten-minute, or 2,300-foot, walk is the maximum distance Americans are willing to walk, while Canadians and Europeans are more apt to walk farther[6] This is consistent with Stringham's findings. Untermann's research also shows that transit passengers are less sensitive to walking distances as service frequency increases. Demographics also has some bearing on willingness to walk. Research shows females, those without driving licenses, and young people are more amenable to walking.

A recent study in Houston underscores the importance of pedestrian amenities as well as the land-use environment in influencing pedestrian behavior (Cervero, 1993a). Downtown Houston has four times the employment density and 23 percent more sidewalk footage per 1,000 workers than Uptown, a suburban activity center six miles west of downtown. And compared to West Houston's Energy corridor, an axial strip along the Katy Freeway corridor dotted with office parks, downtown Houston is nearly ten times as dense and averages 76 percent more sidewalks. Downtown Houston also has skywalks and such pedestrian amenities as parks, civic plazas, benches, street sculptures, and overhangs and trees as protection from the elements. The built environment is also more interesting downtown, consisting of an assortment of street-level shops, eateries, and storefronts. Conversely, walking in Uptown and the Energy Corridor requires long waits at busy intersections, wading through expansive surface parking lots, and passing undistinguishable urban spaces. As a consequence, walking/cycling accounts for around 30 percent of all trips (made outside of buildings) in downtown Houston, compared to 7 percent in Uptown and only 1.9 percent in West Houston.[7] The research estimated that every 10 percent increase in pedestrian amenities (e.g., lineal feet of sidewalk, number of benches) is related to a 15 percent decline in motorized trip-making.

6. Summary Evidence on Ridership and Walk Access by Distance

The various studies cited in this chapter provide a fairly consistent set of insights on how ridership and levels of walk access vary by distance to rail transit stations. Figure 2.1 merges some of the findings from earlier work. In general, it appears that, all else equal, ridership potential is highest for developments within about one-third of a mile of a station, though the "impact zone," based on Stringham's work, can exceed a half mile in radius.

These studies also provide useful public policy insights. A radius of 3,000 feet around a station encompasses about 1,200 acres of land. Intense development of this amount of land can yield direct ridership and revenue benefits. From their analyses, JHK & Associates (1987, p. 81) estimated that "a new 200,000 square foot office building in downtown will generate nearly 300,000 additional transit trips per year, valued at approximately $500,000 in transit revenue. A similar building near a close-in suburban station would generate over $200,000 in transit revenues annually." This, they estimate, would further result in a reduction of some 500,000 vehicle miles of travel within the region. Moreover, based on Washington Metrorail's success at joint development to date, such transit-linked development would also likely yield important lease revenue income to the transit agency, which in 1990 exceeded $8 million annually for the system as a whole (Cervero et al., 1992).

Studies to date also consistently show that transit-oriented residential development has more impact on ridership than office development. This is likely attributable to abundant free parking at most suburban office buildings and the higher time-value of walking at the work end of a trip. Moreover, evidence shows that the origin-destination pattern of trips is also crucial to winning over commuters to rail. Residents living near rail will most likely ride transit if they work downtown, and those working near rail will most likely commute by transit if they reside within several miles of

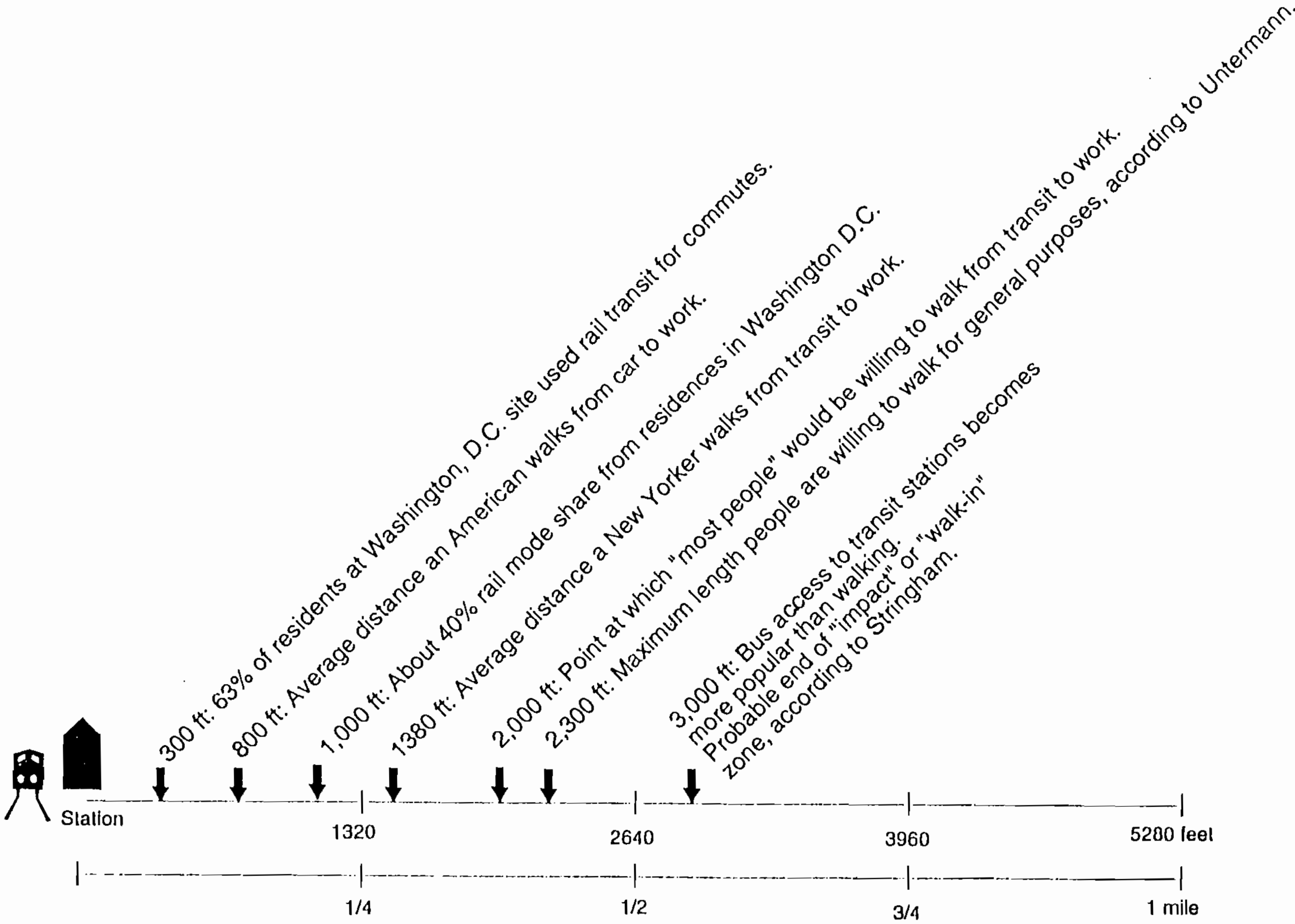


Figure 2.1

Empirical Evidence on Ridership by Distance

---

a station. The influence of land-use and parking factors on transit modal split as well as the origin-destination patterns of trips are thought to be important factors in urban California as well, and thus receive particular attention in this study.

7. Research on Transit Demand and Transit-Linked Development: Macro-Scale Analyses

In addition to studies on the specific topic of ridership by proximity to rail stations, a larger body of literature exists on the relationship between transit-supportive land-use patterns and ridership. The final two sections of this chapter summarize this research, divided into two scales of analyses: macro (regional) and intermediate (activity center/neighborhood).

A seminal study on how land-use patterns and the built environment influence transit ridership was carried out by Pushkarev and Zupan (1977). Based on inter-modal comparisons of transit unit costs and inter-city comparisons of transit trip generation rates, the authors developed a set of land use thresholds necessary to financially justify different types of transit investments. They found the key land-use determinants of transit demand to be the size of a downtown (in non-residential floorspace), the distance of a site to downtown, and residential densities. To justify a light rail line, for instance, Pushkarev and Zupan concluded that minimum residential densities of 9 dwelling units per acre were needed to serve a downtown with at least 20 million square feet of non-residential floorspace.

Another macro-level study that has received considerable attention in recent years is the work of Newman and Kentworthy (1989). Using cross-national comparisons, they found average urban densities to have a strong impact on modal choice and energy consumption. Low-density U.S. cities like Houston and Phoenix, for instance, were found to average around seven times as much gasoline fuel consumption per capita as comparable-size European cities. This work has been heavily criticized, however, notably for the lack of statistical controls that account for other factors influencing fuel consumption, such as differences in the fuel efficiencies of U.S. versus foreign fleets (Gordon and Richardson, 1989; Gomez-Ibanez, 1991).

8. Research on Transit Demand and Transit-Linked Development: Intermediate-Scale Analyses

A number of recent studies have examined land use and transportation relationships at a more intermediate scale, focusing on specific corridors, activity centers, and neighborhoods. In his analysis of suburban activity centers in metropolitan Toronto, Pill (1983) found dense office and residential subcenters like North York and Scarborough to be vital in maintaining multi-directional flows on the regional rail transit network. Cervero (1986) documented the effects of rapid suburban office growth on travel behavior during the 1980s, finding that most campus-style office parks with abundant free parking averaged transit modal splits under 2 percent, a finding also confirmed by Fulton (1986) in his analysis of inter-suburban commuting in the U.S. Cervero and Landis (1992) found dramatic changes in travel behavior when workers were relocated from a rail-served to a non-rail-served setting: transit work trip modal splits fell from 58 percent to 3 percent among several thousand office workers who were relocated from downtown San Francisco (well-served by BART) to three suburban campus locations (not served by BART, and poorly served by bus).

Several recent studies have enriched our understanding of how the built environments of suburban activity centers influence travel behavior. Hooper's (1989) survey of six mixed-use activity centers across the U.S. found transit modal splits to be consistently below 10 percent, although there was considerable variation across individual properties within centers. In the case of Bellevue, Washington, for example, 37 percent of workers carpooled and 12 percent rode bus transit at an office project which restricted and priced parking. At a nearby building where parking was abundant and free, only 11 percent of workers shared rides or patronized transit. In another study, Cervero (1989) classified America's largest suburban activity centers on the basis of size, density, land uses, and site designs, and found that density, followed by levels of land-use mixture, were the most important predictors of transit modal choice. A more recent study by Douglas (1992) found transit modal shares for work trips to be four times higher in downtown Washington (served by rail) than in a suburban downtown (Bethesda, also served by rail), and four times higher in suburban Bethesda than in a suburban office park (Rock Springs Park, unserved by rail).

Several recent studies of subregions in the San Francisco Bay Area further underscore the importance of urban densities in influencing travel behavior. Using the Bay Area's 33 superdistricts, Harvey (1990) (using 1981 data) and Cervero (1993b) (using 1990 data) both found strong negative exponential relationships between residential densities and the amount of vehicular travel— on average, a doubling of densities resulted in a 30 percent decline in VMT/household. In another study, Holtzclaw (1990) found a similar pattern across five Bay Area communities with similar income profiles —residents of a dense part of San Francisco logged, on average, only one-third as many miles on their private vehicles each year as residents of Danville, an East Bay suburb.

Another line of recent empirical work conducted at the neighborhood scale has sought to measure the degree to which neo-traditional communities affect travel behavior. These efforts have been hampered, however, by the fact that most neo-traditional communities are still under construction or being planned. Thus work to date has focused mainly on comparing travel behavior between long-established traditional communities and nearby 1960s-style suburban neighborhoods. A study of San Francisco Bay Area travel found a dramatic difference in mode choice between standard suburban developments and traditional, pre-World War II neighborhoods with mixed uses and moderate to high densities (Fehrs and Peers Associates, 1992). In traditional neighborhoods, 23 percent of trips were made on foot and 22 percent were by transit. By comparison, suburban residents made only 9 percent of trips by foot and 3 percent by transit. Another study in the Bay Area, however, found no significant difference in the share of walk trips to retail centers among neo-traditional versus conventional suburban neighborhoods (Handy, 1992).

A recent study in Montgomery County, Maryland provides the best insights to date on the travel characteristics of traditional neighborhoods that are served directly by rail transit (MNCPPC, 1992). The authors compared transit modal splits between three transit-oriented traditional neighborhoods (served by the B&O commuter railroad or a trolley line) and three nearby newer neighborhoods with a branching system of streets designed for auto access. The study found that residents of the transit-oriented communities patronized transit between 10 percent and 45 percent more than residents of nearby auto-oriented neighborhoods.

To conclude, research on the influence of land uses on transit ridership has been carried at varying scales and textures of analyses. Much of the evidence to date is consistents, revealing a fair amount of elasticity between transit ridership and such factors as proximity and density. The research that follows aims to build upon this body of evidence.

Notes

[1]Regular customers were defined as those riding BART to work at least four times per week. Among surveyed residents, 43 percent said they commuted by BART at least once a week.

[2]The transit commute modal splits greatly exceeded those of the respective cities as a whole: Pleasant Hill — 10.2 percent; Union City —6.7 percent; Fremont —4.5 percent; and South Hayward —7.8 percent.

[3]The surveyed station areas were slightly different in the 1989 survey. In addition to Silver Spring and Crystal City stations, residential developments near Ballston, Twinbrook, and Grosvenor Metrorail stations were surveyed in 1989.

[4]This was compared to a transit market share of only 14 percent in the original 1987 survey.

[5]Unlike the JHK study of Washington Metrorail, this earlier work concentrated on the travel characteristics of both adults and school-age children within households.

[6]A mile can be walked in about 20 minutes at the brisk pace of three miles per hour, which translates to 265 feet per minute. In typical urban settings with intersections, grades, and other pedestrian traffic, the average pace tends to be slower.

[7]These statistics are based on a 1987 survey prepared by the Rice Center for Urban Mobility Research (1987).

Chapter Three

Study Methodology and Survey Approach

1. Introduction

To conduct a complete study of the travel characteristics of residents, workers, and shoppers around urban rail stations in California, a rich database is needed. Since no pre-existing secondary data sources were available, primary data needed to be collected, mainly in the form of responses to surveys sent to targeted populations. Sites which met minimum threshold requirements (e.g., size and distance to stations) were initially identified and screened. Surveys were then designed, pre-tested, revised, and administered to the occupants of chosen sites. Since this study also sought to examine the relationship between transit ridership and the land-use characteristics of station-area developments, data on individual buildings and sites also had to be collected.

Overall, this study is very data-intensive, as are the materials presented in this report. This chapter describes the methods, approaches, and survey instruments used in carrying out this research. Many of the technical details are found in the endnotes of this chapter.

2. Study Approach

This work seeks to understand ridership relationships for transit-focused development at two levels: (1) among individuals living, working, or shopping near stations; and (2) among sites near rail stations. Accordingly, two scales of data collection and analyses were carried out in this research —disaggregate (person-level) analyses, and aggregate (site-level) analyses.

The disaggregate data compiled on individuals living, working, and shopping near rail stations allowed a fairly rich perspective on travel behavior and choices. With these data, both descriptive/exploratory and inferential research was carried out. The descriptive/exploratory analyses describe rail transit users in terms of their socio-economic profiles, trip purposes, and other travel characteristics, including the geographic patterns of travel and modes of access to stations. The inferential analyses aim to model travel choices by predicting the degree to which such factors as trip origins and destinations, incomes, and parking costs influence people's decisions to patronize rail transit.

The aggregate data support the study of travel and land-use relationships— specifically, the link between station-area built environments and transit usage. These analyses are more hypothetical-deductive in nature, testing the extent to which higher densities, closer proximity, mixed land uses, below-normal parking supplies, and other spatial and environmental attributes encouraged rail usage. The site-level data also provides insights into the spatial dimensions of travel, such as the degree to which ridership falls with distance away from stations.

Both individual-level and site-level analyses focused on three types of land uses: residential, offices, and retail establishments. For residential projects, self-administered questionnaires were mailed to the tenants in all units of selected buildings. For office projects, self-administered surveys were distributed to employees by managers of participating companies. For retail establishments, personal interviews were conducted at store entrances or in the interior common areas of large shopping plazas, depending on characteristics of each site.

The most important consideration in the design of the data collection program was to minimize response biases and errors. Although all surveys have some degree of sampling error, a careful data collection effort can reduce the chances of obtaining biased results and distortions. Two important tactics were used in this regard. One was extensive pre-testing, to improve the clarity and phrasing of questions and to edit out any suggestive or biasing questions. Surveys of different lengths —long, medium, and short — were designed and administered in order to evaluate how response rates and survey completeness varied.[1] Where possible, those participating in the pre-test were interviewed to obtain feedback on the clarity and scope of the surveys. Surveys were revised to remove ambiguities. Because it became clear many pre-testers did not have the stamina to carefully fill out the entire long version of the surveys, the medium-length version was eventually opted for. The second tactic used in reducing the chance of bias was to cast the survey as input into a general study of transportation in each metropolitan area. Defining the surveys as an instrument for studying rail transit usage might have biased modal choice responses. Thus, no direct reference was made to BART, Sacramento Regional Transit, the San Diego trolley, or any other transit agencies or systems in the survey titles, headings, or descriptions.

The next several sections discuss the process followed in selecting sites and collecting survey data for each land-use type. Maps showing the regional locations of selected sites are also presented.

3. Site Selection

The two principle criteria used to select sites were:

(1) ***Maximum distance***. Sites had to lie within two-thirds mile of stations, and ideally within the more walkable distance of one-third mile.
(2) ***Minimum size***. The following thresholds were used for different land uses: residential — at least 75 dwelling units; office — at least 10,000 square feet or 100 employees; and retail — at least 400,000 square feet of commercial floorspace.

Thus, the universe of this research consists of fairly large-scale developments within a reasonable walking distance of urban rail stations in the selected metropolitan areas.

Candidate sites were identified and screened through a combination of windshield surveys, existing databases, and discussions with local planners and transit officials. Initially, a database on transit-based housing compiled by the National Transit Access Center (NTRAC) at the University of California at Berkeley was used in identifying possible candidates that met threshold criteria.[2] Since office uses were not included in the NTRAC databases, and to further check on whether other candidate sites existed, windshield surveys were conducted along main roads within a one-third-mile radius of stations.[3] Lastly, planners within each transit agency and within the local governments of cities with urban rail stations were asked if they knew of suitable sites that met the pre-set criteria. Through these efforts, we were able to obtain a fairly complete listing of candidate residential, office, and retail buildings.[4]

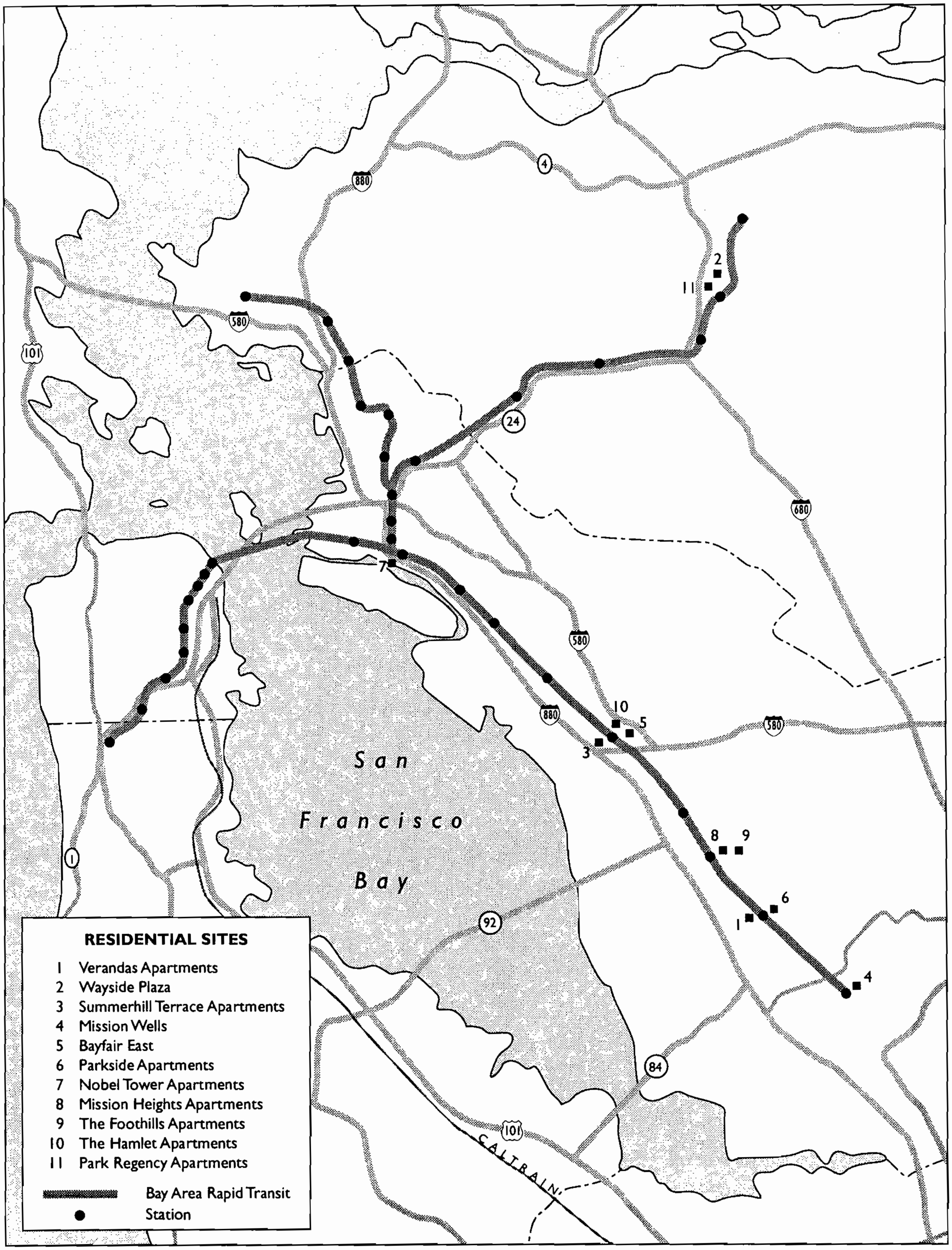
Among the candidate sites, the deciding factor in whether a site was chosen to be surveyed was the willingness of building owners or agents to participate in the survey. This was crucial, especially for the office sites, in order to have access to residential addresses, employees, or (in the case of the retail surveys) private premises. Property-owner endorsement was also necessary in order to obtain specific site information (such as rents, parking supply, building square footage). And perhaps as important, owner support, in the form of a letter encouraging tenants to participate in the survey, was viewed as necessary in order to increase the survey response rate. Thus, property-owners or their agents (property managers and leasing firms) of all candidate sites were approached about participating in the survey. We emphasized the fact that all survey responses would be anonymous and would be combined to provide summary aggregates. We also emphasized the importance of collecting such data in order to be able to shape public policy and improve regional transportation services. In all, 27 of the candidate residential sites and 18 of the candidate office sites were chosen for the study. Three retail sites near BART stations were also selected.

Maps 3.1 to 3.10 depict the rail systems, stations, and general locations of all surveyed sites, broken down among metropolitan areas. Surveyed residential sites and nearby stations are shown in Maps 3.1 to 3.5. Surveyed office sites are shown in Maps 3.6 to 3.10.

4. Residential Surveys

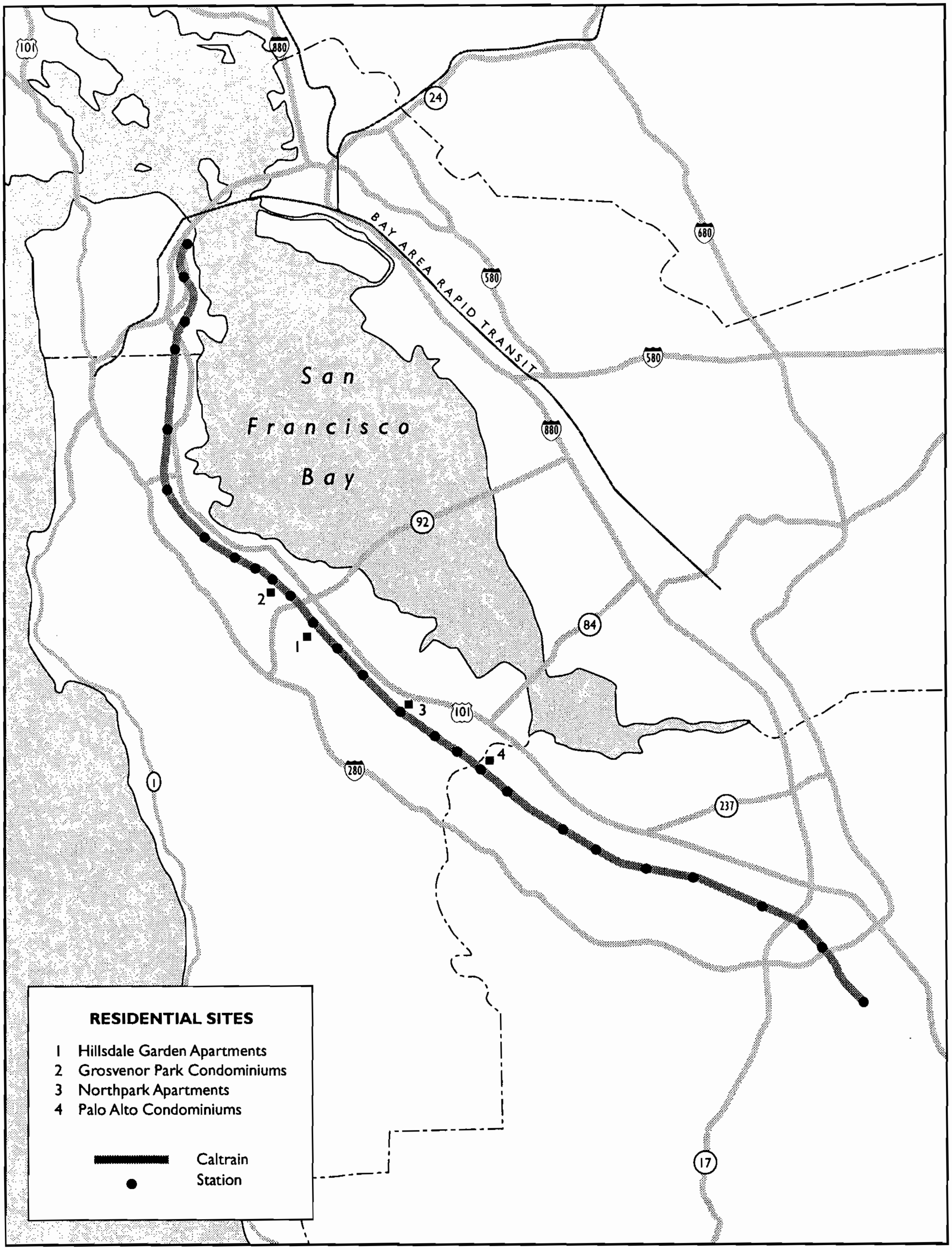
The residential sites that were surveyed are listed in Table 3.1. Housing projects varied in terms of proximity to station[5] (361 to 3,527 feet) and size (76 to 892 units). All of the projects contained rental units, except for six sites which were condomiums.[6]

As shown in Table 3.2, final response rates varied considerably, from just 5 percent in the case of The Hamlet Apartments near BART's Bayfair station to 54 percent in case of La Mesa Village Plaza. The average response rate was 18.4 percent; while a higher response rate would have been preferred, this was viewed as acceptable for a mailback survey and was considerably higher than the 12.6 percent response rate obtained by JHK & Associates (1989, p. 48) in their most recent survey of housing units near Washington Metrorail stations. Adjusting for vacancies among surveyed housing units, the true response rate among occupied units was closer to 25 percent. Table 3.2



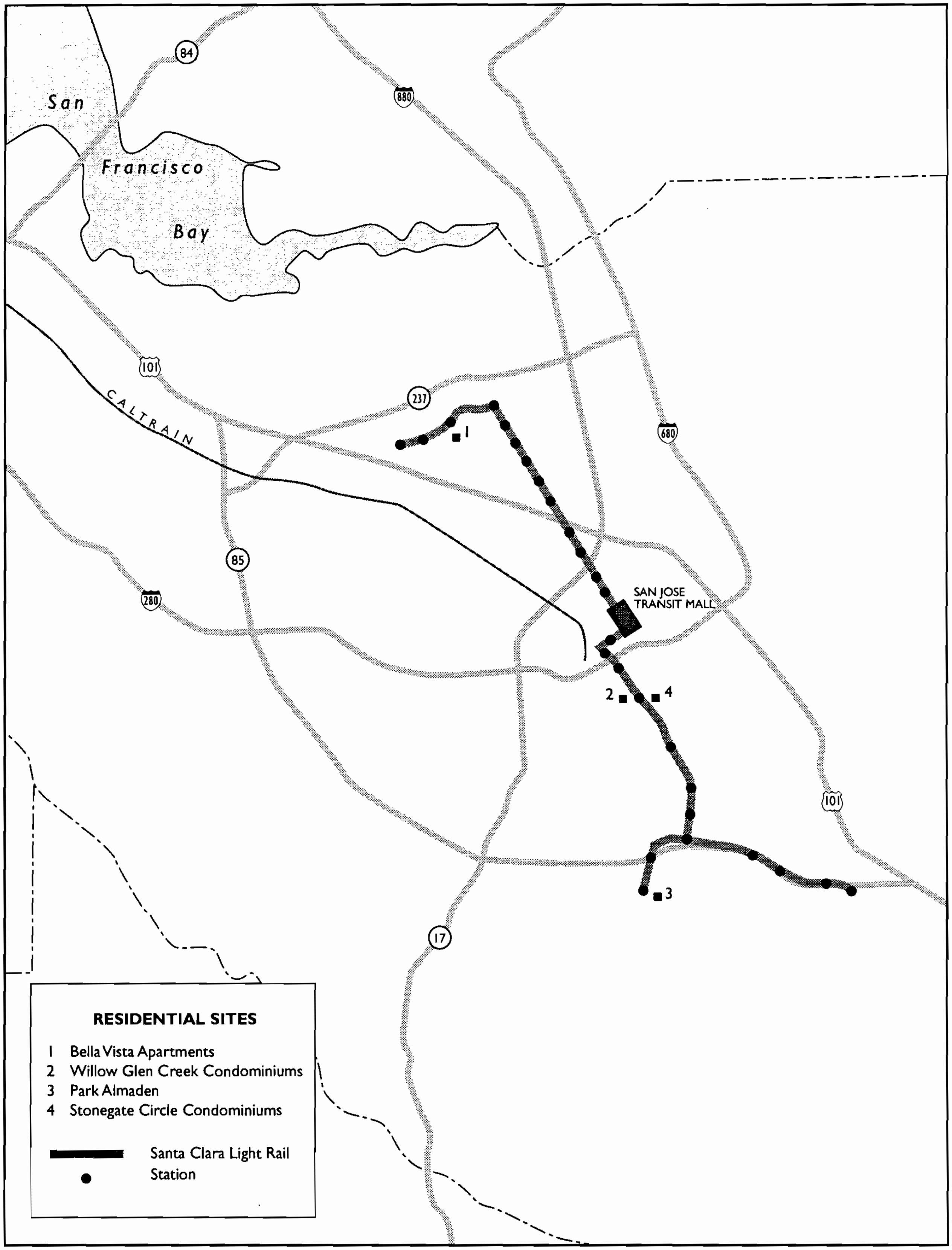
Map 3.1

Surveyed Residential Sites, BART System



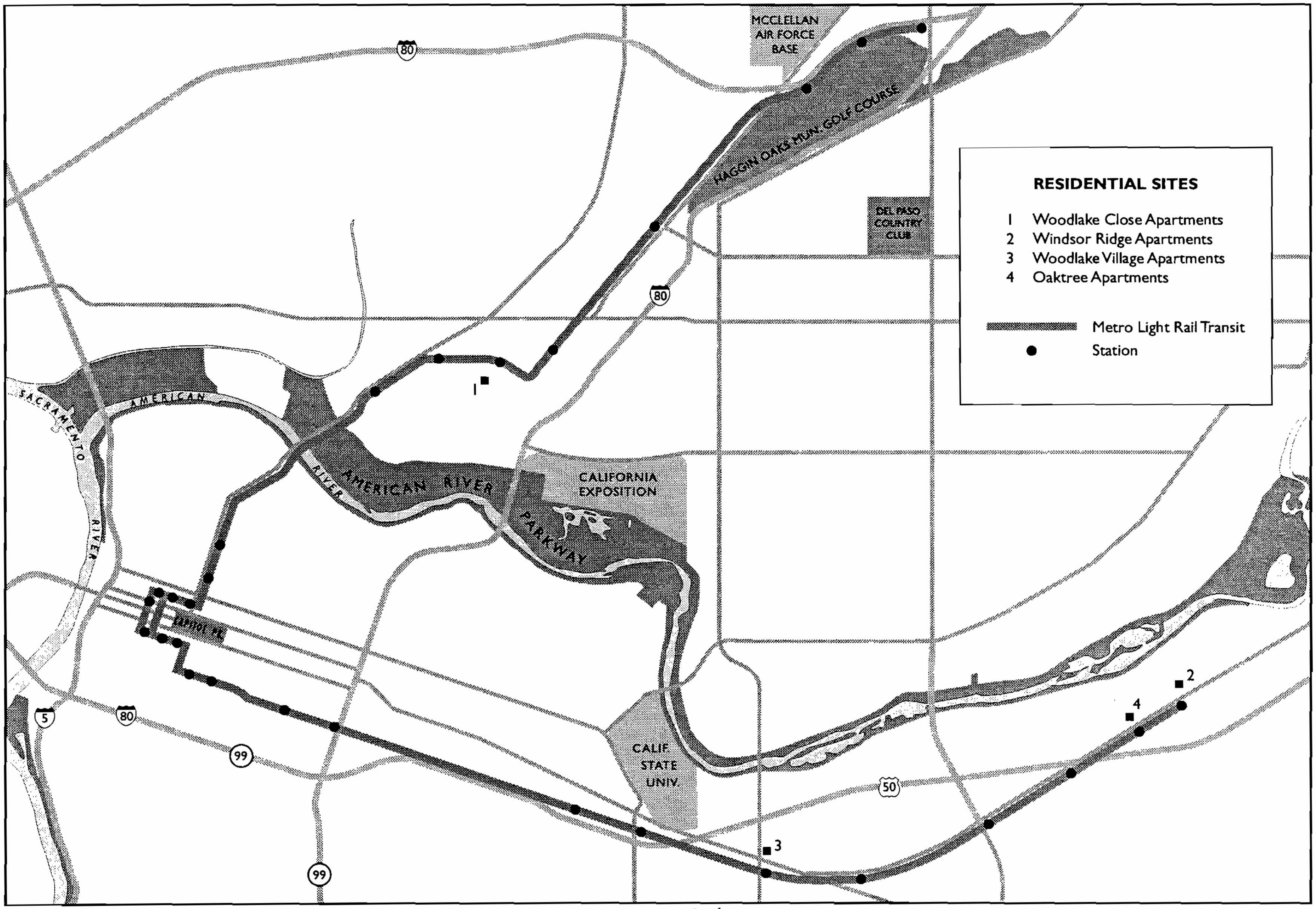
Map 3.2

Surveyed Residential Sites, CalTrain System



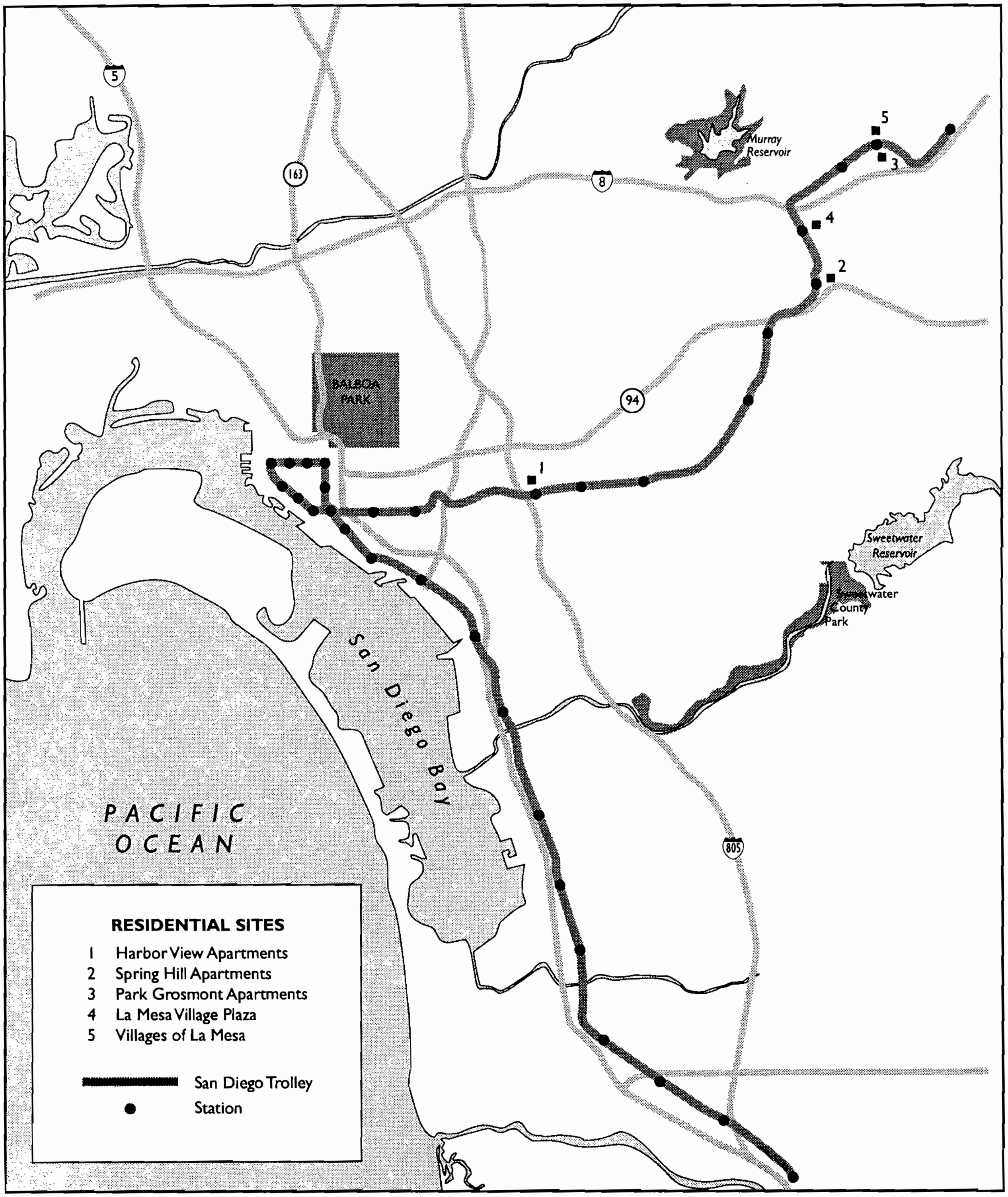
Map 3.3

Surveyed Residential Sites, Santa Clara County Light Rail System



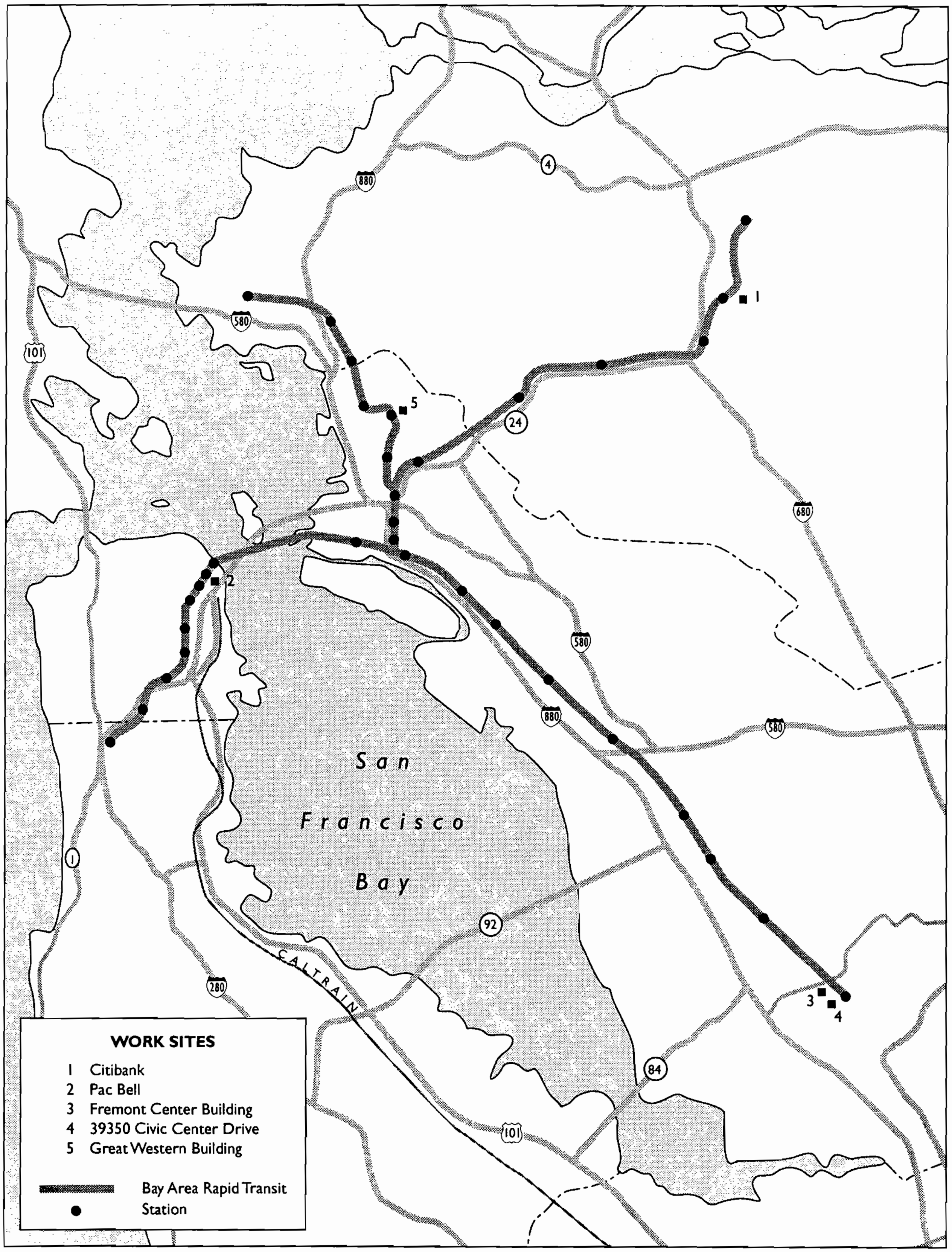
Map 3.4

Surveyed Residential Sites, Sacramento Light Rail System



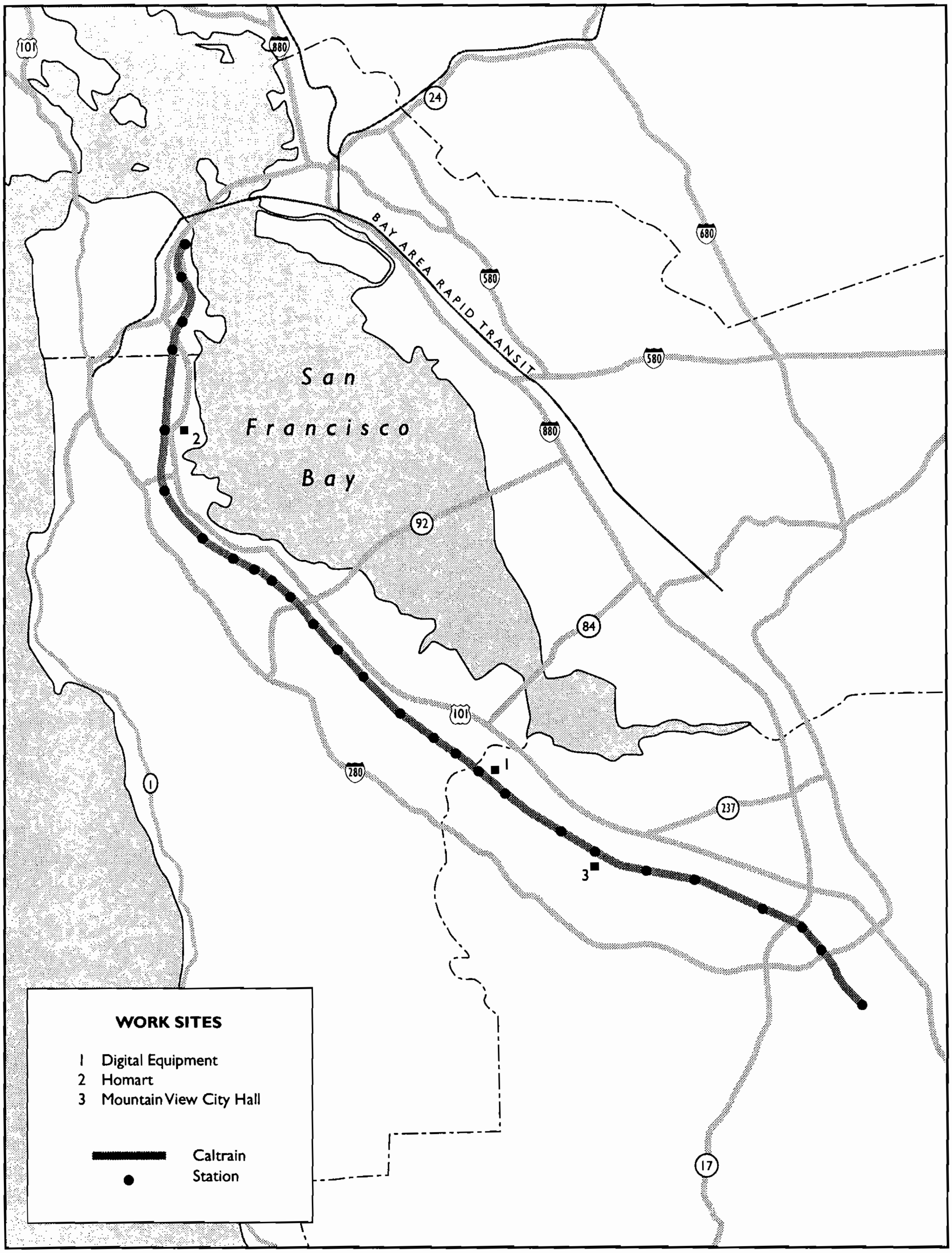
Map 3.5

Surveyed Residential Sites, San Diego Trolley System



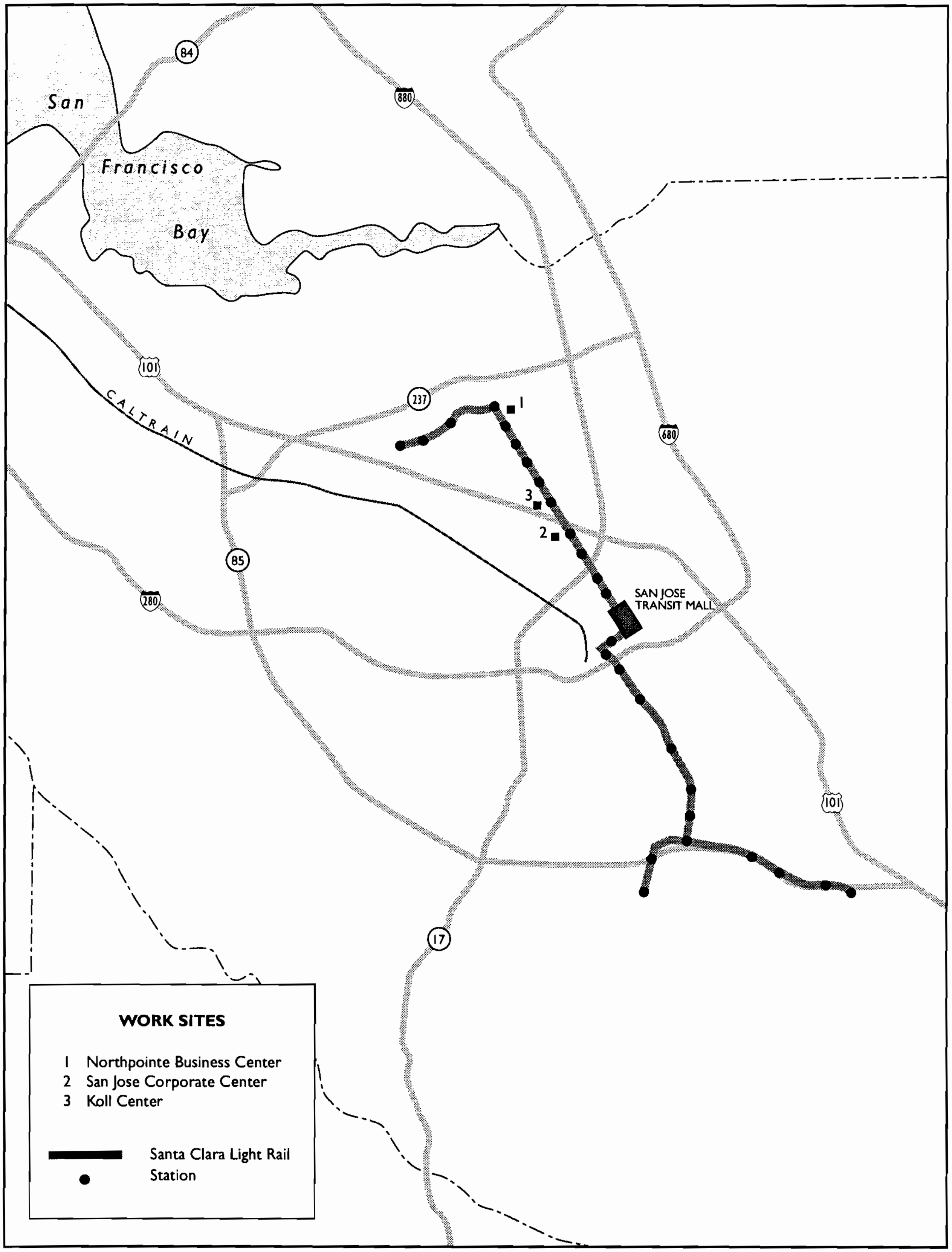
Map 3.6

Surveyed Work Sites, BART System



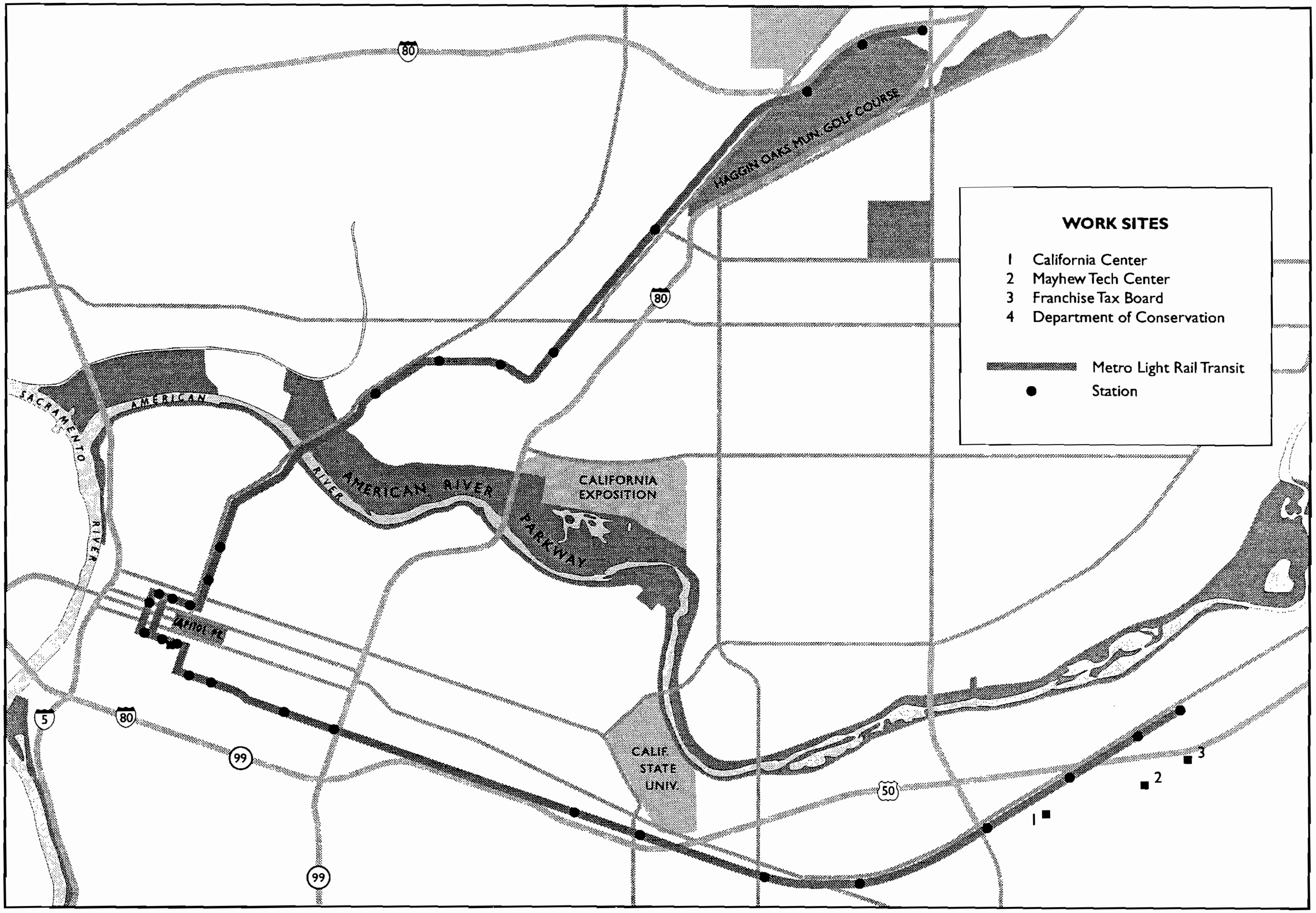
Map 3.7

Surveyed Work Sites, CalTrain System



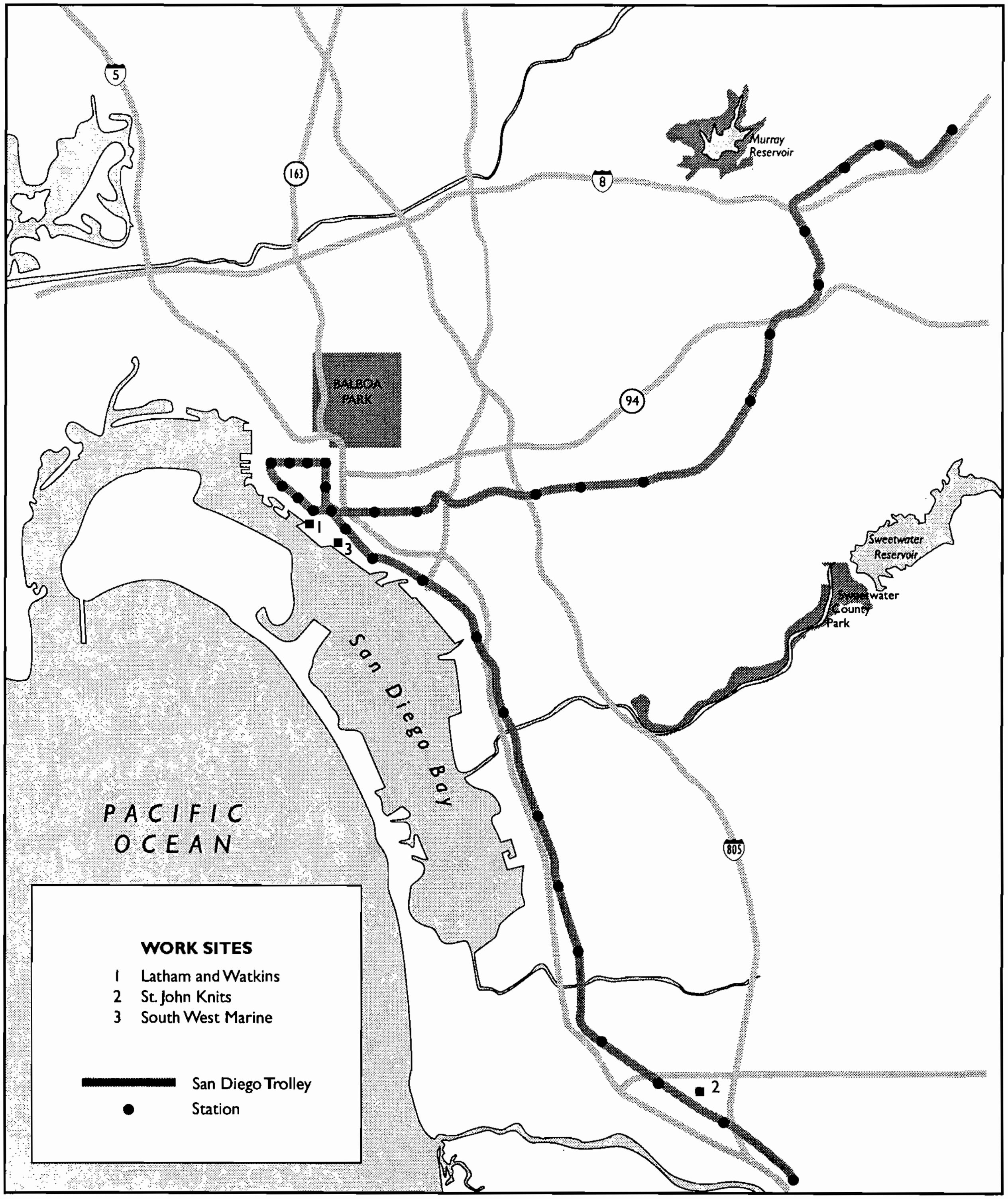
Map 3.8

Surveyed Work Sites, Santa Clara County Light Rail System



Map 3.9

Surveyed Work Sites, Sacramento Light Rail System



Map 3.10

Surveyed Work Sites, San Diego Trolley System

Table 3.1

Surveyed Residential Projects

Site	Station	Distance to Station (ft.)[1]	No. of Units	Housing Type[2]
BART				
Mission Wells	Fremont	1,148	390	Apts.
Verandas Apts.	Union City	1,104	380	Apts.
Parkside Apts.	Union City	598	210	Apts.
The Foothills Apts.	South Hayward	774	190	Apts.
Mission Heights Apts.	South Hayward	2,618	145	Apts.
Summerhill Terrace Apts.	Bayfair	3,105	100	Apts.
Bayfair East	Bayfair	2,805	135	Apts.
The Hamlet Apts.	Bayfair	1,050	150	Apts.
Nobel Tower Apts.	Lake Merritt	1,330	195	Apts.
Wayside Plaza	Pleasant Hill	1,756	155	Condos
Park Regency Apts.	Pleasant Hill	1,568	890	Apts.
CalTrain				
Hillsdale Garden Apts.	Hillsdale	2,175	695	Apts.
Grosvenor Park Condos.	San Mateo	1,789	145	Condos
Northpark Apts.	Broadway	1,155	510	Apts.
Palo Alto Condos.	Palo Alto	1,511	85	Condos
Santa Clara County Light Rail				
Bella Vista Apts.	Lick Mill	3,527	400	Apts.
Stonegate Condos.	Tamien	1,330	85	Condos
Willow Glen Creek Condos.	Tamien	1,759	135	Condos
Park Almaden Condos.	Almaden	987	590	Condos
Sacramento Light Rail				
Woodlake Close Apts.	Royal Oaks	1,730	75	Apts.
Oaktree Apts.	Tiber	476	145	Apts.
Woodlake Village Apts.	Power Inn	2,925	650	Apts.
Windsor Ridge Apts.	Butterfield	1,322	110	Apts.
San Diego Trolley				
Villages of La Mesa	Amaya Dr.	598	385	Apts.
Park Grossmont	Amaya Dr.	2,643	160	Apts.
La Mesa Village Plaza	La Mesa Blvd.	316	90	Condos
Spring Hill Apts.	Spring St.	845	95	Apts.

[1]This is measured walking distance by the shortest path from the center of the residential complex to the nearest ticket machine of the nearest transit station.

[2]Apts. = rental apartments; Condos = owner-occupied condominiums.

Table 3.2

Residential Site Response Rates

Site	Station	No. of Questionnaires: Sent Out[1]	Returned	Percent Returned	Cover Letter?
BART					
Verandas Apts.	Union City	201	37	18	N
Wayside Plaza	Pleasant Hill	131	63	48	Y
Park Regency Apts.	Pleasant Hill	291	41	14	N
Mission Wells	Fremont	218	44	20	Y
Summerhill Terrace Apts.	Bayfair	57	6	11	N
Nobel Tower Apts.	Lake Merritt	185	17	9	Y
Bayfair East	Bayfair	92	15	16	N
The Hamlet Apts.	Bayfair	111	5	5	N
The Foothills Apts.	South Hayward	164	31	19	N
Mission Heights Apts.	South Hayward	94	14	15	N
Parkside Apts.	Union City	101	12	12	N
CalTrain					
Hillsdale Garden Apts.	Hillsdale	271	72	27	Y
Grosvenor Park Condos.	San Mateo	92	15	16	N
Northpark Apts.	Broadway	510	30	6	Y
Palo Alto Condos.	Palo Alto	101	20	20	Y
Santa Clara County Light Rail					
Bella Vista Apts.	Lick Mill	345	107	31	Y
Stonegate Condos.	Tamien	75	10	13	N
Willow Glen Creek Condos.	Tamien	119	30	25	N
Park Almaden Condos.	Almaden	178	27	15	N
Sacramento Light Rail					
Woodlake Close Apts.	Royal Oaks	62	99	551	Y
Windsor Ridge Apts.	Butterfield	99	26	26	Y
Woodlake Village Apts.	Power Inn	551	89	16	Y
Oaktree Apts.	Tiber	115	12	10	N
San Diego Trolley					
Spring Hill Apts.	Spring St.	72	15	21	N
La Mesa Village Plaza	La Mesa Blvd.	68	37	54	Y
Villages of La Mesa	Amaya Dr.	324	78	24	Y
Park Grossmont	Amaya Dr.	131	10	8	N
27-Site Total		4,758	885	18.4%	

[1]In some instances, not all units were surveyed because of prior knowledge that units were vacant.

shows a general pattern that response rates were highest if a letter of endorsement was included from the property owner or building manager.

A copy of a residential survey is shown in Appendix A.[7] The surveys have four main sections. The first gathered background socio-demographic information on each respondent's household, the respondent, and one other household member at least 16 years old. The second set of questions elicited information on the travel characteristics of both the respondent and the other person for up to three trips. Travel information was requested for "main" trips on a single weekday; it was up to the respondent to decide what was a main trip. The third section obtained information on the respondent's commute trip only (e.g., fares, availability of free parking at the work site) as well as more detailed information (such as mode of station access) for respondents who commuted by rail. Lastly, information was gathered on respondents' prior residence within the metropolitan area.

5. Office Surveys

A similar survey approach was followed for office projects. Table 3.3 shows that the 18 surveyed office projects varied considerably in terms of distance to stations (50 to 3,408 feet)[8] and size of firm (75 to 3,000 employees).

For offices surveyed, it was necessary in all cases to first secure the approval of management. This was usually arranged through initial telephone inquiries and follow-up letters that explained the purpose of the survey and guaranteed confidentiality. Once management agreed to participate, questionnaires were delivered to individual offices. We personally visited most offices to further explain the survey procedure and to iron out any logistical questions. Also, a letter explaining the purpose of the survey was left with the employer's contact person. In most cases, employers distributed surveys with their own cover letter. Employers also typically collected surveys. Between one and two weeks after surveys were delivered, we arranged to pick them up at the site. In some cases employers mailed all responses back in bulk, and in other cases they had their employees mail them back individually. Our primary concern was to work with the employer to make the surveying process the least cumbersome and disruptive as possible. All office surveys were administered during the October-November 1992 and February-March 1993 periods in order to avoid the holiday period and California's rainiest months.[9]

For nine of the 18 offices surveyed, all employees were given surveys. For the remaining nine offices, a subset of employees was sampled at the request of the employer. Where only a part of the workforce was surveyed, every effort was made to ensure that surveys were representative across the full spectrum of positions within the firm. Table 3.4 shows the average response rate was 22.7 percent, ranging from 4 percent to 63 percent. Even though data on a small share of the total work force was obtained for some office sites, the number of responses were adequate in abso-

Table 3.3

Office Sites Surveyed

Site	Station	Distance to Station (ft.)[1]	No. of Workers
BART			
Citibank	Pleasant Hill	655	350
Pac Bell	Montgomery St.	490	550
Fremont Center Building	Fremont	1,005	300
39350 Civic Center Drive	Fremont	1,475	235
Great Western Building	Berkeley	50	275
CalTrain			
Digital Equipment	Palo Alto	455	400
Homart	South San Francisco	3,410	1,800
Mountain View City Hall	Mountain view	2,810	150
Santa Clara County Light Rail			
Northpointe Business Center	Tasman	490	75
San Jose Corporate Center	Metro/Airport	425	600
Koll Center	Karina Court	420	1,000
Sacramento Light Rail			
California Center	Watt/Manlove	1,130	1,000
Mayhew Tech Center	Tiber	1,870	605
Franchise Tax Board	Butterfield	1,565	3,000
Dept. of Conservation	8th and K Streets	365	398
San Diego Trolley			
Latham & Watkins	Gaslamp	675	160
St. John Knits	Iris Ave.	3,200	106
Southwest Marine	Bario Logan	2,080	1,200

[1]This is measured walking distance by the shortest path from the entrance of the office complex to the entrance of the nearest ticket machine of the nearest transit station.

lute terms. Even in the case of Homart near the South San Francisco CalTrain station, where the response rate was only 4 percent, data on the travel characteristics of 72 employees were obtained.

Appendix B shows an example of an office survey. Surveys were customized for each metropolitan area. Questionnaires covered four primary areas. First, they obtained background socio-demographic and household data for each employee respondent. Second, information was collected on each employee's trip to work for the day in which the survey was filled out. Third, data were collected on up to two midday trips made the prior work day. And lastly, information on commuting

Table 3.4

Office Response Rates

Site	Station	No. of Questionnaires: Sent Out[1]	Returned	Percent Returned
BART				
Citibank	Pleasant Hill	280	114	41
Pac Bell	Montgomery St.	80	46	58
Fremont Center Building	Fremont	300	79	26
39350 Civic Center Drive	Fremont	235	124	53
Great Western Building	Berkeley	270	48	18
CalTrain				
Digital Equipment	Palo Alto	370	56	15
Homart	South San Francisco	1,800	72	4
Mountain View City Hall	Mountain view	150	77	51
Santa Clara County Light Rail				
Northpointe Business Center	Tasman	75	33	44
San Jose Corporate Center	Metro/Airport	250	54	22
Koll Center	Karina Court	175	48	27
Sacramento Light Rail				
California Center	Watt/Manlove	1,000	156	16
Mayhew Tech Center	Tiber	500	95	19
Franchise Tax Board	Butterfield	200	111	56
Dept. of Conservation	8th and K Streets	250	115	46
San Diego Trolley				
Latham & Watkins	Gaslamp	160	87	54
St. John Knits	Iris Ave.	106	94	89
Southwest Marine	Bario Logan	150	21	14
18-Site Total		6,351	1,430	22.5

patterns for those who worked at a different location within the past three years in the same metropolitan area was compiled.

6. Retail Surveys

At surveyed retail establishments, pedestrian intercept surveys were used — those walking by were asked if they would be willing to answer a few questions on transportation. Surveys were designed to be brief so as not to overly inconvenience shoppers. Thus, only essential data were gathered on trip purpose, mode of access, where people arrived from, and several demographic variables. Surveys were conducted in mid-fall (October and November) 1992, and late-winter/ early-spring (March and April) to avoid peak shopping periods and California's rainy winter months.[10]

Ideally, surveys would have been conducted in the most central location of each retail complex to minimize the possibility of selection biases. However, because of management concern, surveyors were instead posted at the major entrances of each site and, where possible, at other areas of heavy traffic.[11]

7. Site Data Collection

For carrying out site-level analyses, travel data were aggregated to produce modal splits and other statistics for each site. Statistics on parking supply, land area, and other physical attributes of sites were, where possible, obtained from building managers or secondary sources. Information of the walking environment between sites and the nearest freeway (e.g., the existence of continuous sidewalks) was gathered in the field. Chapter Seven discusses how these data were gathered in more detail.

8. Closing

This chapter described the procedures followed in collecting the kinds of data necessary to study the ridership characteristics of transit-focused development in California. The data collection effort, to the degree possible, sought to minimize biases and to provide a representative sample of large-scale residential, office, and retail complexes within walking distance of California rail transit stations. The next three chapters present the empirical results from these surveys.

Notes

1For the residential surveys, long questionnaires elicited more detailed travel diary information —data on up to four trips for up to three household members. The medium-length survey obtained information on up to three trips for up to two household members. The short survey obtained information on up to three trips, but only for the person completing the survey. Several questions on travel behavior prior to residing near a rail station were also asked.

2See Bernick and Carroll (1991) and Bernick and Munkres (1992) for discussions of these databases.

3Where possible sites were identified, researchers sought to talk with an on-site property manager or leasing agent about the size of the project to see whether it met minimum threshold requirements. This also provided some feedback on whether property-owners at these sites might be willing to participate in the survey.

4Several other factors influenced which sites were chosen. Among residential sites, only those with market-rate housing units, either rental or owner-occupied, open to the general population, were considered as possible candidates. Thus, the following types of housing were not surveyed: public and subsidized housing projects; institutional housing, such as military quarters or university dormitories; and specialized housing, i.e., for retirees and older Americans. Among office sites, private businesses were surveyed, except for a city government office in Mountain View and two state offices in Sacramento. And among retail sites, only large retail plazas with at least one major anchor tenant near BART rail services were surveyed.

[5]This was measured as the shortest walkable distance from the center of the project to the closest station entrance.

[6]At residential projects, establishing a contact was desirable primarily because this person could provide an accurate list of the addresses (without names) of each of the units in the complex, and could sometimes indicate which units were vacant. The expectation that official sanction from the management of projects might induce greater and more detailed survey responses form residents led us to request that, if possible, a letter be drafted by the management to accompany our survey. Twelve of the project managers or owners obliged us in this respect. Where property managers offered little or no cooperation, it often proved effective to establish contact directly with property owners and developers. When this failed, it was sometimes possible to obtain the addresses from a direct visit to the site, then to mail the surveys in the form of a letter.

Surveys were originally mailed to all housing units in each of the 27 projects between October and November 1992. Each survey was sent out in a small envelope which included a cover letter explaining the purpose of the survey and guaranteeing responses would be treated anonomously. For twelve of the surveyed housing developments, letters of endorsement from property owners or building managers were also included with the surveys. Surveys were designed as self-addressed, prepaid forms that could be easily folded into letter-sized envelope-like mailings. The response rate after the first round of mailings was around 12 percent. In February and March 1993, a mailback survey was sent to all households in the 27 projects that did not respond to the original survey.

Households were not surveyed during December and January, which are among the rainiest months in California and also are holiday periods. To obtain representative periods for studying travel choices, October, November, February, and March were chosen. Also, survey forms had a special code which allowed us to monitor which housing units responded. A number of non-responses were because units were vacant.

[7]Questionnaires were customized for each area —titles and references to rail transit systems varied.

[8]Distance to station was measured as door-to-door walking distance —along the shortest walkable path from the main entrance of the office to the main entrance of the nearest transit station.

[9]Some employers requested that surveys be carried out at specific dates.

[10]Surveying shoppers during the December holiday season and rainy months could have biased modal split statistics since rail transit is less likely to be used for large-volume holiday shopping or during periods of inclement weather.

[11]At retail survey sites it was necessary to establish contact with the management of the project. Private firms at two of the projects reserved the exclusive right to conduct surveys within the boundaries of the projects themselves. An agreement was reached with the maangement as to where and when surveying could take place.

Chapter Four

Travel Characteristics of Californians Living Near Urban Rail Transit Stations

1. Introduction

This chapter summarizes findings from the survey of the 27 selected housing projects near near rail transit stations in California. As discussed in the previous chapter, travel and socio-economic data were elicited for up to two adult household members from each surveyed residence. For each household, travel data were requested for the "main trips" made the day before the survey was filled out.[1] For the most part, statistics presented in this chapter are summarized by combining data for all adult respondents (up to two per household).

2. Background: Household, Demographic, and Employment Characteristics

Of the nearly 900 households for which reasonably complete survey responses were obtained, the mean household size was 1.89, with relatively little variation across the five rail systems studied (Table 4.1). This was considerably smaller than the 1990 weighted-average household size of 2.71 for the San Francisco-Oakland-San Jose CSA, Sacramento MSA, and San Diego MSAs combined.[2] Forty-four percent of the surveyed station-area households had a single resident.

Table 4.1

Station-Area Household Characteristics

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Household Size						
Average	1.89	1.84	1.83	2.01	2.03	1.80
(Std. Dev.)	(0.78)	(0.84)	(0.69)	(0.84)	(0.74)	(0.75)
No. of Vehicles Available						
Average	1.53	1.41	1.61	1.57	1.58	1.58
(Std. Dev.)	(0.72)	(0.70)	(0.67)	(0.83	(0.73)	(0.66)

BART=Bay Area Rapid Transit
SCCTA=Santa Clara County Transit Authority, light rail
CalTrain=CalTrain, commuter rail
RT=Sacramento Regional Transit, light rail
SDT=San Diego Trolley

On average, surveyed residences had 1.53 vehicles[3] available for use by household members (Table 4.1). This was also less than the weighted-average of 1.73 for the three metropolitan areas. Only 1 percent of the surveyed households had no vehicles available. Around one-quarter had a single vehicle and nearly one-half had two vehicles. In general, those residing near urban rail stations in California appear to have moderately high levels of automobility.

Among all adult members for which travel data were obtained,[4] the average age was 36.7 years (Table 4.2). Respondents[5] living near CalTrain stations were, on average, more than 17 years older than those living near Sacramento RT stations. Around 55 percent of the respondents, moreover, were women. Women respondents were the majority across all five rail systems; in the case of Sacramento RT, six of ten respondents were women. Ethnically, whites made up the overwhelming majority of respondents, particularly so in the cases of SCCTA, CalTrain, and RT.[6] Only in the case of BART did non-whites represent more than one-third of the survey respondents. Slightly higher shares of white residents were surveyed than the weighted-average for the three metropolitan areas.[7] Most of the surveyed sites were in the suburbs, however, and these percentages do closely approximate the ethnic compositions of many suburban areas in the three metropolitan areas.

Table 4.2

Station-Area Trip-Maker Demographic Characteristics

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Age						
Average	36.7	34.8	33.4	47.6	30.0	40.7
(Std. Dev.)	(15.2)	(13.2)	(10.3)	(18.5)	(11.6)	(17.8)
Percent Female	55.5	56.2	51.2	56.8	60.4	53.6
Ethnicity -- Percent						
African American	5.3	10.3	1.3	2.4	6.7	2.7
Asian American	9.7	18.5	9.0	1.2	7.9	3.8
Hispanic	5.3	5.3	3.0	9.5	4.4	5.6
White	78.5	65.3	84.6	84.5	79.8	88.5
Other	1.1	0.6	2.1	2.4	0.0	0.5

On average, around 85 percent of the respondents were employed either full-time or part-time (Table 4.3). While unemployment rates were relatively high in some station neighborhoods (particularly in the cases of CalTrain and SDT), this is partly explained by the fact that some respondents were university students. Nearly one-half of the employed respondents worked as managers or professionals. Compared to the average for the three metropolitan areas, there were relatively large numbers of managers, professionals, and service workers living near rail stations and relatively

Table 4.3

Station-Area Trip-Maker Employment Characteristics

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Employment Status -- Percent						
Full-Time Employed	73.6	82.0	86.8	63.9	58.2	64.2
Part-Time Employed	12.0	6.7	7.2	9.3	29.0	14.5
Unemployed	14.4	11.3	6.0	26.8	12.8	21.2
Occupations -- Percent						
Manager/Professional	48.1	49.9	65.4	40.0	34.8	40.6
Clerical/Accounting	21.4	21.7	17.7	29.0	20.8	25.5
Sales/Services	10.5	9.5	7.2	10.3	18.0	9.2
Other	20.0	18.8	9.7	20.7	26.4	24.7
Annual Salary -- Percent						
0-$20,000	25.9	21.6	10.4	23.2	51.0	31.2
$20,000-$40,000	40.2	41.4	30.6	42.4	38.6	49.4
$40,000-$60,000	24.4	30.7	37.5	20.5	8.8	13.8
$60,000-$80,000	6.7	5.1	15.5	4.6	1.6	3.2
> $80,000	3.4	1.2	6.0	9.3	0.0	2.4

small numbers of clerks, secretaries, and laborers.[8] In the case of SCCTA, nearly two-thirds were managers or professionals; this reflects the large share of engineers and other professionals employed in the semiconductor and computer industries in northern Santa Clara County (Silicon Valley), which is directly served by the light rail system. CalTrain averaged relatively large shares of station-area residents who are secretaries, clerical workers, and accountants while RT had a comparatively large share of sales, services, and other[9] workers.

Annual salaries varied considerably among station-area residents across the five urban rail systems (Table 4.3). The median salary ranges, broken down by rail system, were: Sacramento RT —$15-20,000; San Diego Transit —$20-25,000; BART and CalTrain — $30-40,000; and SCCRT — $40-50,000. The relatively low salaries of RT's station-area residents corresponds with their high shares of service and sales workers, while SCCTA's relatively high salaries corresponds to the high shares of management and professional workers residing near its stations.

3. Trip Characteristics of Station-Area Residents

Modal Splits

Of the over 2,500 "main trips" for which survey data were obtained, 15 percent of the trips were by rail transit (Table 4.4). Modal splits varied widely by system, however. In the case of BART, over one-quarter of the main trips taken by station-area residents were by rail transit, whereas for

Table 4.4

Modal Splits for All Trips by Station-Area Residents

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Percent of Trips by:						
Drive Car	73.0	64.4	84.8	69.9	72.7	76.5
Ride Car	5.0	2.1	4.4	5.8	6.8	9.3
Rail Transit	15.0	26.8	6.7	9.7	12.0	11.5
Bus	2.2	2.8	0.4	5.2	3.2	0.5
Walk	2.7	3.2	0.7	7.2	1.6	1.9
Bike	0.7	0.1	1.2	0.6	0.3	1.4
Other	1.3	0.6	1.7	1.7	0.0	2.5
No. of cases	2,560	707	569	370	449	375

SCCTA, rail's market share was less than 7 percent. Overall, those residing near California's rail stations appear to be fairly auto-dependent—over three-quarters relied on a car, either as the driver or a passenger, for their main trips. Most of the remaining modes, like bus transit, walking, and cycling, accounted for a small share of total trips. The remainder of this chapter concentrates on identifying those factors which are most closely associated with rail usage by station-area residents. The wide variation in rail transit usage suggests a number of factors, like vehicle availability and trip destination, might explain mode choices among station-area residents in California.

The modal splits of individual residential projects (for all trips and work trips) are summarized in Tables A4.1 to A4.5 in the Appendix for the five rail systems. The highest rail modal split —78.6 percent of all trips and 86.4 percent of work trips—was found for the Oaktree apartment complex in Sacramento. Other station-area residential projects with relatively high rail modal splits (for all trips) were:

- BART: Wayside Apartments, Pleasant Hill —45.0%
  The Hamlet Apartments, San Leandro —35.7%
  Park Regency Apartments, Pleasant Hill —31.5%
- SCCTA: Bella Visa Apartments, San Jose —20.0%
- CalTrain: Northpark Apartments, Burlingame —27.0%
- SDT: Spring Hill Apartments, San Diego —35.1%

Overall, rail modal splits were found to be fairly high for the surveyed residential projects when compared to citywide and regional averages from the 1990 journey-to-work censuses. For instance, urban rail transit accounted for 5.0 percent of 1990 work trips made by residents of the three counties (San Francisco, Alameda, and Contra Costa) within the BART service district;[10,11] for the surveyed residents living near BART stations, rail transit was used for 32.1 percent of work trips —more than six times as much as the three-county average. Those residing near SCCTA stations used light rail transit for 7.0 percent of trips, compared to the countywide 1990 average of 3.0 percent for all modes of transit.[12] CalTrain's work-trip modal split for station-area residents was 36.6 percent, considerably above the 1.7 percent of work trips via CalTrain by all residents of San Mateo County. And the transit modal splits for work trips by station-area residents in Sacramento and San Diego of 18.2 and 14.2 percents greatly exceeded their respective metropolitan averages of 2.4 and 3.3 percents.[13]

Overall, rail modal splits appear to be higher for these station-area housing projects than for other residences near rail stations. Table 4.5 shows the 1990 share of work trips made by rail for all residences within a one-half-mile radius of a BART station in the three BART-served counties. The three-county total was around 18 percent — that is, fewer than one out of five of Bay Area commuters living within one-half mile of a BART station rode BART to work. The share in San Francisco was more than twice as high as in Contra Costa County. By comparison, for the 11 large-scale housing projects near BART that were surveyed in this study, 32.1 percent of work trips were by BART. Differences could be due to the fact that most occupants of the surveyed sites were renters, whereas a much larger share of all residences near BART consists of single-family homes. To the degree homeowners are financially better off than renters, then differences could be due to income. They might also reflect the fact that larger-scale projects tend to be in denser, more transit-conducive physical environments, a topic that is explored in Chapter Seven.

At a finer-grain level, the community, the strong transit orientation of station-area residents is even more evident. For the Bay Area, Table 4.6 compares the work-trip transit modal splits for

Table 4.5

Rail Modal Splits for Residences Within One-Half Mile of a BART Station, 1990 Work Trips[1]

City	BART Work Trips[2]	Percent of All Work Trips
Alameda	4,621	17.3
Contra Costa	2,494	11.3
San Francisco	5,024	25.5
Three-County Total	12,139	17.8

NOTES:

[1]The one-half-mile radius was approximated by taking block groups within census tracts around every BART station in each county.

[2]A BART trip was interpreteted to be one designated as the category of "subway or elevated train" in the U.S. Census journey-to-work statistics.

SOURCE: 1990 U.S. Census, STF-3A.

Table 4.6

Comparison of Work-Trip Transit Modal Splits Between Bay Area Station-Area and Citywide Residents

City	Work-Trip Transit Modal Splits (%) for: Station-Area Residents [3]	Citywide [4]
BART[1]:		
Pleasant Hill	46.7	16.0
Fremont	12.9	2.7
Union City	27.5	3.8
Hayward	25.7	4.4
San Leandro	27.7	6.1
Oakland	10.0	6.1
CalTrain[1]:		
San Mateo	26.2	2.8
SCCTA[2]:		
San Jose	7.0	3.6

NOTES:

[1]Statistics presented for urban rail transit trips only.
[2]Statistics presented for all transit modes combined, including both rail and bus transit.
[3]Based on survey results from 1992-93, aggregated according to city jurisdiction.
[4]1990 statistics. Sources: Metropolitan Transportation Commission (1993) and 1990 journey-to-work census statistics, STF-3A. All statistics exclude workers who work at home.

station-area residents in the listed cities to the citywide averages from the 1990 journey-to-work census. Overall, it is evident that workers residing near rail stations in California patronize rail transit far more than their counterparts residing farther away from stations but within the same city. *On average, residents living near stations were five times as likely to use rail transit to get to work as the average worker living in the same city, and in some cases as much as seven times as likely*. These statistics seem to bode favorably for the ability of concentrated residential development around California's rail stations to substantially induce transit ridership.

Trip Purpose

Around 70 percent of the surveyed trips of station-area residents were work-related—either to or from work (Table 4.7). No other trip purpose category exceeded 10 percent of trips. By comparison, work and work-related trips accounted for only 26.3 percent of all vehicle trips in the 1990 Nationwide Personal Transportation Survey (NPTS) (Hu and Young, 1992). Clearly, the trip data obtained from California station-area residents were skewed toward work trips. Since data were elicited only for "main trips," survey respondents evidently viewed journeys to work as their most important ones.

Table 4.7

Trip Purpose for All Trips by Station-Area Residents

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Percent of Trips:						
To Work	42.6	45.2	45.0	39.7	38.1	41.4
Return Home	27.4	32.3	27.5	23.7	24.0	24.3
Personal Business	5.1	4.5	4.9	7.2	4.5	5.6
Meal	3.1	2.0	5.4	1.9	3.4	2.4
Shopping	4.8	4.3	5.6	6.3	3.8	4.5
Medical	1.7	1.1	1.1	5.0	0.9	1.9
Social-Recreation	6.4	4.7	5.4	7.7	8.3	8.3
Other	8.8	5.8	5.1	8.3	17.0	11.2

Trip Lengths, Times, and Speeds

Surveyed trips were fairly long—on average, 13 miles over a 29-minute period, at a speed of 25.5 mph (Table 4.8). These compare to the 1990 NPTS averages of 9.0 miles (for all trips), 19.7 minutes (for work trips only), and 27.4 mph (for work trips). The longest (and fastest) trips were taken by those residing near BART stations while the shortest (and slowest) trips were made by those living near Sacramento RT stations. Travel performance varied little by trip purpose (though work trips tended to be longer and slower) and considerably by mode of transportation. On average, rail trips were 25 percent longer and, in terms of door-to-door travel time, 65 percent slower than trips made by automobile.

Table 4.8

Trip Length, Times, and Speeds for All Trips by Station-Area Residents

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Trip Length (Miles)						
Average	13.0	19.4	9.9	12.2	8.4	10.8
(Std. Dev.)	(11.9)	(13.9)	(10.0)	(11.8)	(8.1)	(8.7)
Trip Time (Minutes)						
Average	28.9	37.4	24.1	27.7	22.1	26.7
(Std. Dev.)	(18.6)	(19.5)	(17.4)	(19.2)	(14.0)	(15.8)
Trip Speed (mph)						
Average	25.5	28.4	24.8	24.3	23.9	24.0
(Std. Dev.)	(16.4)	(19.3)	(14.1)	(15.6)	(16.3)	(13.1)

Time of Day

Around 56 percent of the sampled trips took place during the peak hours of 6-9 am and 3-6 pm (Figures 4.1 and 4.2). Station-area residents riding rail transit tended to travel during peak periods more than residents traveling by either automobile or bus (Figures 4.3 and 4.4). The high degree of peakedness reflects the fact that a majority of the surveyed trips were for work purposes. Figure 4.4 also shows that relatively high shares of trips made by foot took place during the mid-day and afternoon.

The time of day of trips varied the most by trip purpose (Figure 4.5). Work trips were made mainly during the peak while personal business was primarily a midday affair. Shopping trips occurred mainly in the afternoon and evenings, and social-recreational trips steadily increased as the day wore on.

No significant differences were found in the temporal pattern of trips by those station-area residents who have staggered work schedules or flex-time privileges versus those who do not. For work trips, however, the temporal distribution of trips was relatively flat (less peaked) for those with flexible work hours.

Spatial Patterns

Maps 4.1 and 4.2 compare the city-by-city origin-destination patterns for all surveyed trips made by station-area residents by rail transit versus automobile in the Bay Area. Rail usage clearly

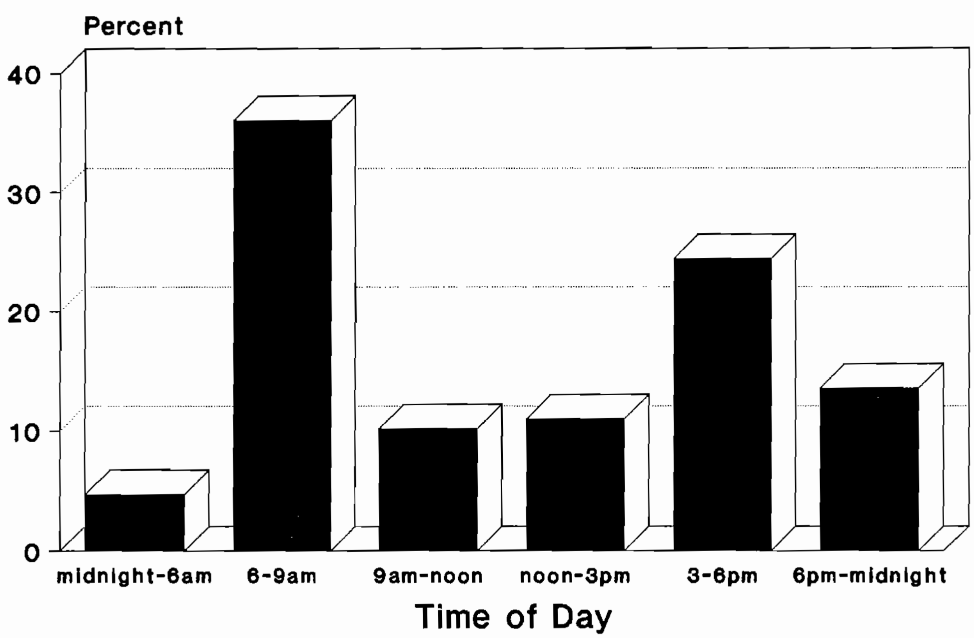


Figure 4.1

Time of Day of Departure: All Trips, Residential Survey

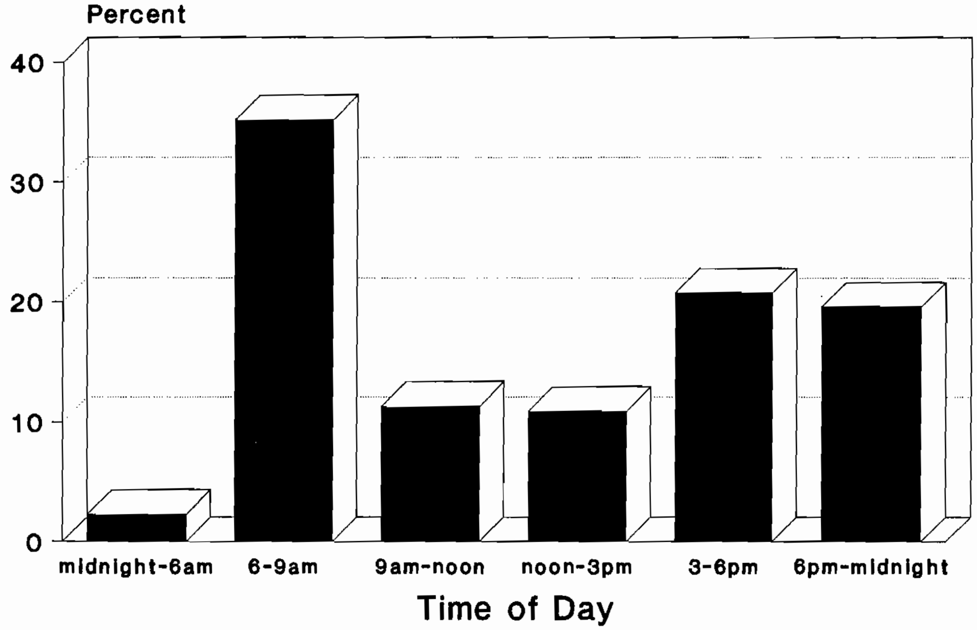


Figure 4.2

Time of Day of Arrival: All Trips, Residential Survey

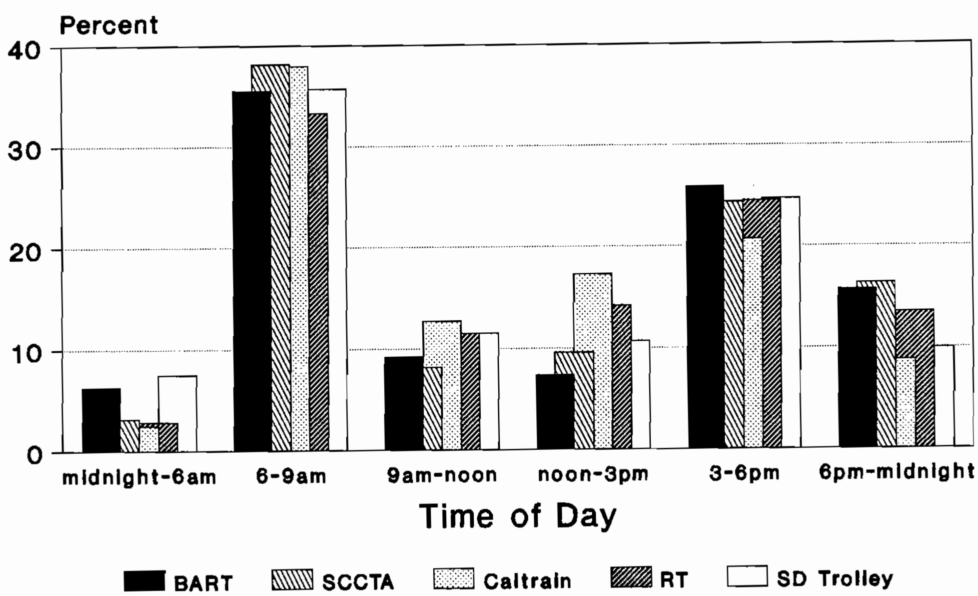


Figure 4.3

Time of Day of Departure by Rail System: All Trips, Residential Survey

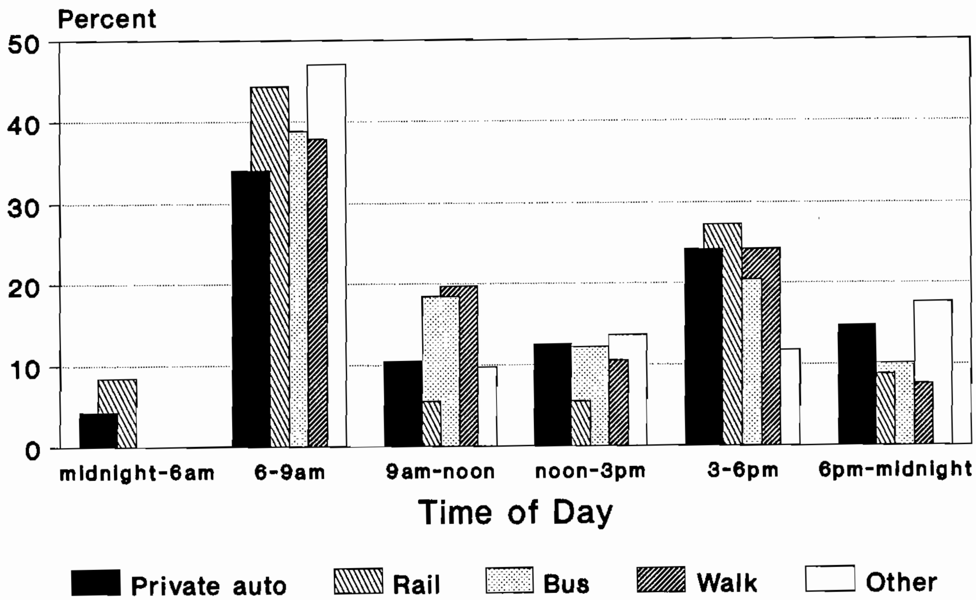


Figure 4.4

Time of Day of Departure by Mode: All Trips, Residential Survey

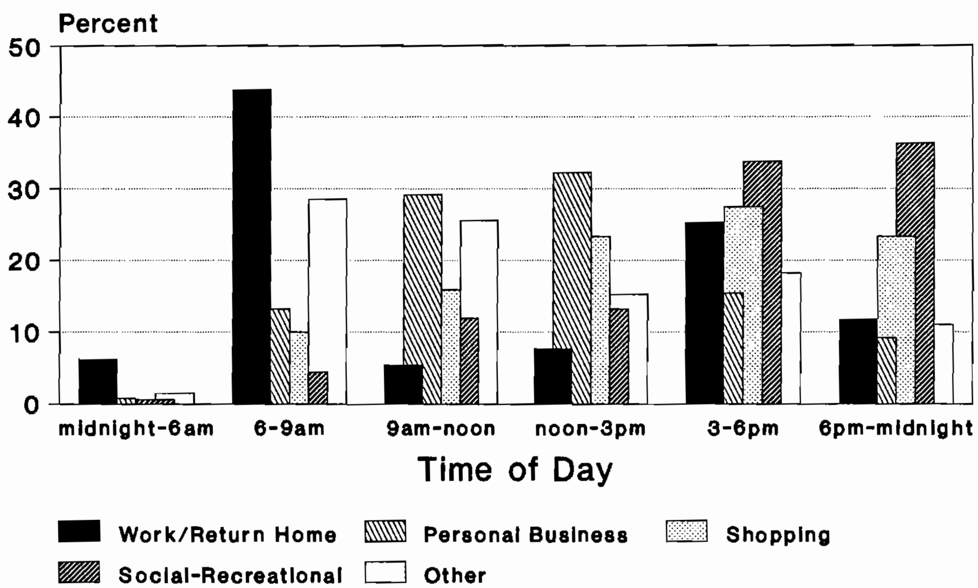
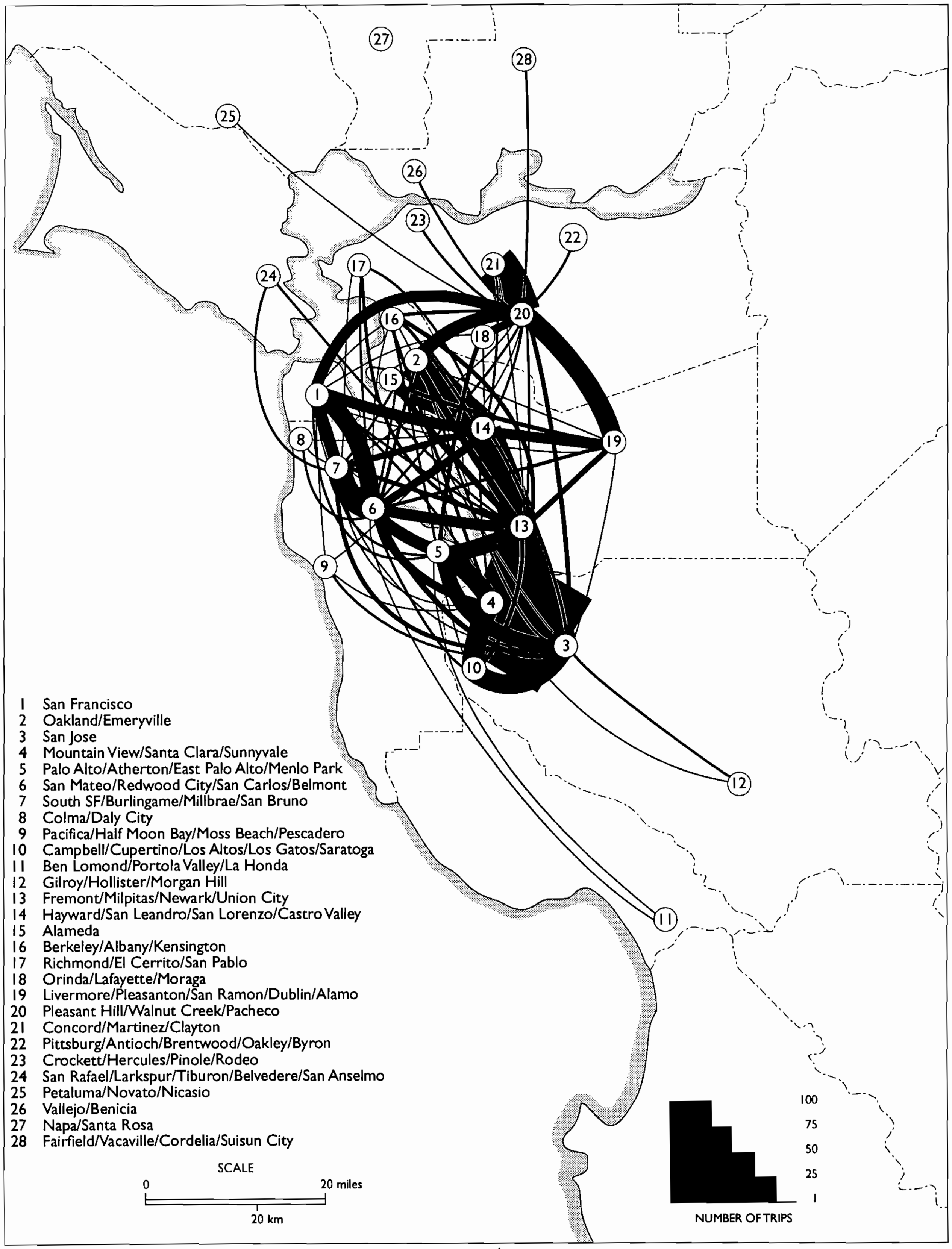


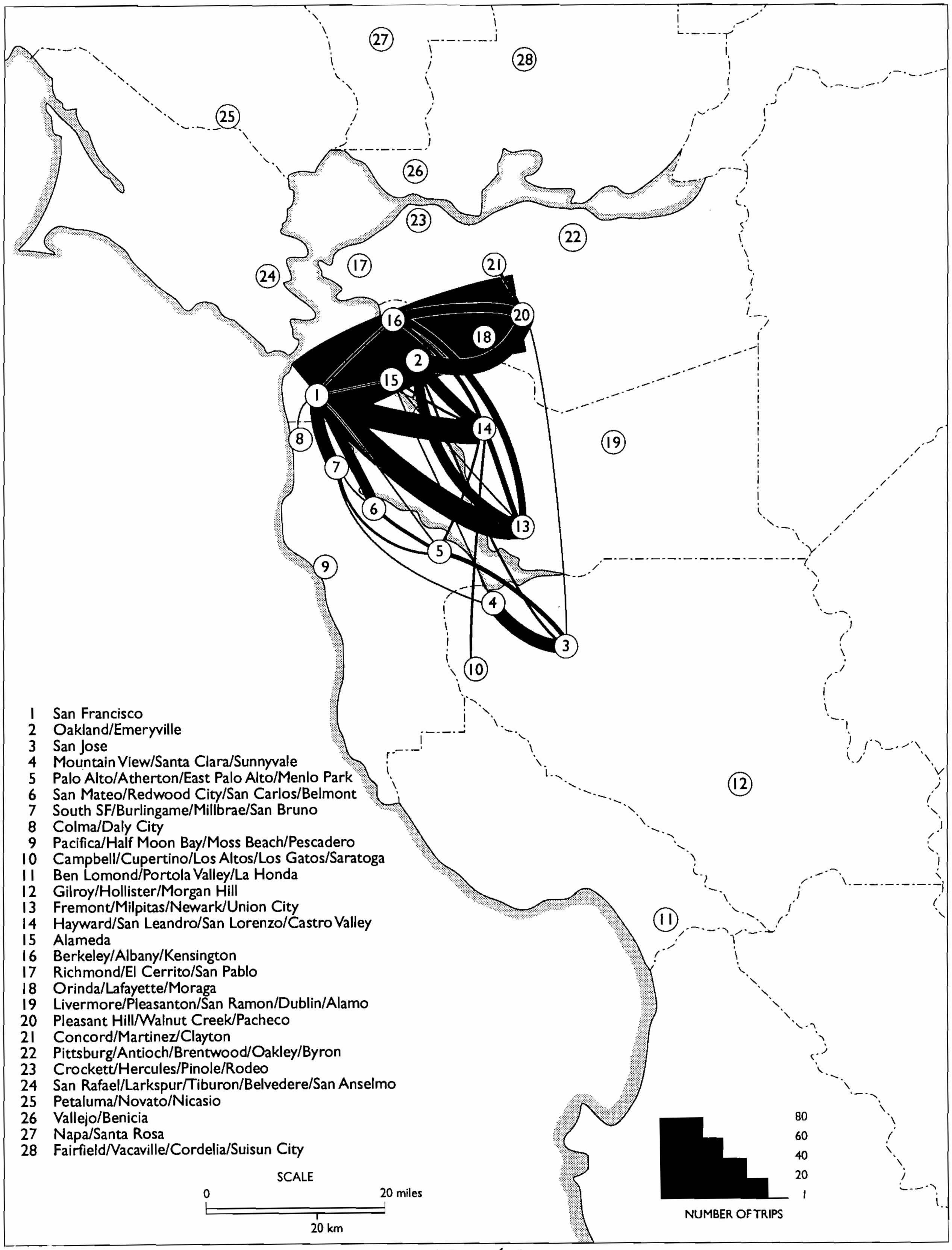
Figure 4.5

Time of Day of Departure by Trip Purpose: All Trips, Residential Survey



Map 4.1

Origin-Destination Patterns for Automobile Trips by Sampled Station-Area Residents in the San Francisco Bay Area, All Trips



Map 4.2

Origin-Destination Patterns for Rail Trips by Sampled Station-Area Residents in the San Francisco Bay Area, All Trips

matches the same corridors served by BART, CalTrain, and SCCTA. Cross-Bay rail travel between San Francisco and the East Bay is particularly dominant. Other significant corridors of rail travel are between central-and-southern Alameda County, San Francisco, and Oakland/Berkeley, and between San Jose and the Silicon Valley. In contrast, Map 4.1 shows that origin-destination patterns for automobile trips made by station-area residents are far more dispersed. The linkage between San Francisco and the East and South Bay areas are far weaker. It is clear that rail transit's spatial market in the Bay Area differs considerably from its chief competitor, the automobile. To the degree trips are between major centers along major rail corridors, then significant numbers of station-area residents will opt for rail travel. To virtually any other destinations, automobile becomes the mode of choice.

Commute Trip Cost Characteristics

The surveys also elicited information on the direct, out-of-pocket cost of work trips made by station-area residents. The average two-way fare paid by station-area residents who commuted by transit was $3.30, with considerable variation among transit trips and across transit agencies (Table 4.9). Average daily parking expenses were slightly higher — $3.60, with significant variation across agencies. Those residing near SCCTA stations only paid, on average, around a quarter per day for parking (and nearly 90 percent parked free at their workplace, a prevalent practice in the office parks scattered throughout northern Santa Clara County). By contrast, residents near BART stations paid about $3.50 per day to park and those residing near RT and SDT stations paid over $5.00 per day for parking. These differences seem to correlate closely with transit modal splits for work trips: workers living near SCCTA stations pay virtually nothing for parking and

Table 4.9

Station-Area Resident Commute Trip Cost Characteristics

	All Survey Respondents	Respondents whose Residences are Near a Rail Station on Following System:				
		BART	SCCTA	CalTrain	RT	SDT
Round-Trip Fares						
Average ($)	3.30	3.52	2.43	3.81	1.82	5.18
(Std. Dev.)	(6.66)	(2.23)	(2.93)	(12.18)	(5.03)	(11.79)
Parking Cost						
Average ($)	3.60	3.45	0.23	0.46	5.26	7.10
(Std. Dev.)	(12.63)	(9.56)	(0.60)	(1.23)	(15.97)	(20.68)
Tolls						
Average ($)	0.65	0.80	0.00	1.25	0.08	0.33
(Std. Dev.)	(0.63)	(0.90)	(0.00)	(1.37)	(0.37)	(0.65)

only 7 percent commuted by rail; those living near BART, RT, and SDT stations pay, on average, significant amounts to park and patronized rail transit for a relatively high share of work trips—32.1 percent, 18.2 percent, and 14.2 percent respectively.

The only other significant out-of-pocket expense incurred was for tolls— on average 65 cents per day. Still, tolls cost considerably less than either parking or fares paid by station-area residents. The highest tolls were incurred by those living near BART and CalTrain stations, many of whom pay a dollar per day to cross the San Francisco-Oakland Bay Bridge and San Mateo-Hayward Bridge.

Transportation Policies at Station-Area Residents' Workplaces

Information on the transportation policies at each of the surveyed station-area residents' workplace was also obtained. As with parking and transit fares, some of the variables in Table 4.10 may help explain variation in transit usage among those residing near California rail stations.

Surprisingly, nearly one-half of the surveyed workers have some form of flex-time privileges. In the case of SCCTA's station-area residents, many of whom are professionals and engineers working in high-technology fields, almost 60 percent had flexible work schedules. By comparison, staggered work schedules were far less common, as were midday car access (a potential induce

Table 4.10

Transportation Policies at Station-Area Residents' Workplaces

	All Survey Respondents	Respondents whose Residences are Near a Rail Station on Following System: BART	SCCTA	CalTrain	RT	SDT
Percent with Flex-Time Privileges	47.8	50.2	59.2	32.9	49.1	34.6
Percent with Staggered Work Hours	14.1	10.6	20.0	8.6	17.9	13.2
Percent Provided a Car for Midday Use	11.6	15.9	7.7	4.9	13.4	11.8
Percent with Transit Allowance	15.2	13.3	12.1	15.7	20.5	17.5
Percent with Free Parking	72.3	63.2	86.6	70.7	67.0	78.5
Daily Parking Costs						
Average	5.03	5.48	13.0	2.39	4.25	4.50
(Std. Dev.)	(4.30)	(4.32)	(10.0)	(2.02)	(1.69)	(2.12)
Monthly Parking Costs						
Average	48.65	59.50	50.00	23.33	45.36	45.71
(Std. Dev.)	(40.59)	(48.38)	(-)	(17.39)	(38.21)	(40.04)

ment to ridesharing and transit usage) and transit allowances (e.g., subsidized monthly passes, free multi-ride coupon books).

As with most Americans, the overwhelming majority of station-area residents received free parking at their workplaces. This varied considerably, however, depending upon the location of the workplace. For those working downtown, fewer than one out of four of station-area residents received free parking, and in the case of those working in downtown San Francisco, less than 10 percent parked free. As mentioned before, free parking was most prevalent in Santa Clara County.

Table 4.10 shows that among the workplaces that did charge for parking, the average daily cost was around $5. Where monthly parking fees were levied, the average was around $50. Almost without exception, parking charges were exacted only in the downtowns and large subcenters of each metropolitan area.

4. Influences of Various Factors on Rail Transit Usage Among Station-Area Residents

This section explores the influences of the sociodemographic, trip-making, travel costs, and policy factors discussed in the previous sections on modal splits and, more specifically, rail usage. The insights gained in this section are used in the section that follows to build a predictive model of rail transit mode choice for station-area residents.

Influence of Household Characteristics

Rail ridership was inversely related to the size of households near rail stations (Table 4.11). Drive-alone auto travel, on the other hand, generally rose with household size. A far stronger predic

Table 4.11

Influence of Household Size on Modal Splits of Station-Area Residents, All Trips

	Household Size			
Modes	1	2	3	4 or more
Rail Transit	17.7%	14.5%	10.8%	10.9%
Bus	2.1	1.9	4.5	1.8
Drove Car	74.6	70.7	75.3	82.7
Rode Car	2.1	7.2	4.2	2.7
Walk	3.0	2.9	1.4	1.9
Other	0.5	1.7	2.8	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%

tor of rail usage, however, was vehicle availability (Table 4.12) — for no-vehicle households near rail stations, 42.3 percent of trips were made by rail transit versus only 3.5 percent of trips for households with three or more vehicles. Conversely, auto travel rose sharply with vehicle availability.

Table 4.12

Influence of Vehicle Availability on Modal Splits of Station-Area Residents, All Trips

	Number of Vehicles Available For Use by Household Members			
Modes	0	1	2	3 or more
Rail Transit	42.3%	19.1%	9.6%	3.5%
Bus	25.8	1.8	0.7	1.8
Drove Car	4.1	69.1	81.7	83.5
Rode Car	14.4	5.5	3.7	8.4
Walk	11.3	2.7	2.4	0.9
Other	2.1	1.8	1.8	1.9
TOTAL	100.0%	100.0%	100.0%	100.0%

Influence of Sociodemographic Factors

Among sampled trip-makers residing near rail stations, women patronized rail transit slightly more than men (Table 4.13). Across ethnic categories, African Americans were most dependent on rail transit, followed by Asian Americans.

Table 4.13

Influence of Gender and Ethnicity on Modal Splits of Station-Area Residents, All Trips

	Gender		Ethnicity				
Modes	Females	Males	African American	Asian American	Hispanic	White	Other
Rail Transit	15.9%	13.7%	24.4%	17.5%	9.6%	14.5%	14.8%
Bus	2.0	2.4	2.5	3.6	8.0	1.4	0.0
Drove Car	71.7	74.8	61.3	65.0	67.2	74.7	81.5
Rode Car	6.8	2.9	0.8	11.2	10.4	4.6	0.0
Walk	2.2	3.3	3.4	0.4	2.4	3.0	3.7
Other	1.4	2.8	7.6	2.2	2.4	1.8	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Persons in the 31-40 year age group utilized rail transit the most (Table 4.14). This no doubt reflects the fact that these individuals, being in the middle stages of the life cycle, make relatively high shares of work trips, the trip purpose category that was most heavily represented in the sample. In general, walk trips were made more often among older trip-makers, and auto-passenger travel was concentrated mostly among the youngest and oldest age groups.

Table 4.14

Influence of Age on Modal Splits of Station-Area Residents, All Trips

	Age					
Mode	0-20	21-30	31-40	41-50	50-70	> 71
Rail Transit	9.5%	12.5%	19.6%	17.5%	17.0%	6.3%
Bus	3.8	1.4	1.0	1.4	6.1	8.4
Drove Car	72.4	77.0	73.0	72.3	59.6	68.4
Rode Car	8.6	5.2	2.7	3.5	8.3	10.5
Walk	2.9	1.8	1.8	2.8	7.2	5.3
Other	2.8	2.1	1.8	2.5	1.8	1.1
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Those working in clerical and accounting occupations were most likely to patronize rail and those employed in sales and the services sector were the least (Table 4.15). In terms of mode choice, occupation often serves as a proxy for income. No strong pattern emerged between rail transit usage and annual salary (Table 4.16). Those in the middle-earnings range averaged the highest rates of rail usage and those in the highest salary bracket averaged the lowest.

Table 4.15

Influence of Occupations on Modal Splits of Station-Area Residents, All Trips

	Occupations			
Modes	Manager/ Professional	Clerical/ Accounting	Sales/ Services	Other
Rail Transit	15.1%	21.4%	9.3%	13.6%
Bus	1.0	1.0	3.1	3.6
Drove Car	76.1	68.5	78.8	69.5
Rode Car	3.7	6.6	5.4	4.3
Walk	2.3	1.5	1.5	5.0
Other	1.8	1.0	1.9	4.0
TOTAL	100.0%	100.0%	100.0%	100.0%

Table 4.16

Influence of Salaries on Modal Splits of Station-Area Residents, All Trips

	Annual Salary				
Modes	0-$20,000	$20,000-$40,000	$40,000-$60,000	$60,000-$80,000	>$80,000
Rail Transit	12.5%	17.3%	15.3%	15.5%	7.9%
Bus	4.6	1.8	0.2	0.0	0.0
Drove Car	70.2	71.9	79.5	79.6	73.7
Rode Car	7.2	4.3	2.3	1.4	10.5
Walk	2.5	2.7	1.4	2.2	7.9
Other	3.0	2.0	1.3	6.3	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Trip Purposes and Modal Splits

Different modes of travel were favored for different trip purposes among station-area residents (Table 4.17). Rail transit was relied upon most heavily for the most essential trip— home-based work trips. For personal business, including medical trips, rail was used by one out of ten station-area residents. For more discretionary travel, such as for shopping and social-recreational activities, fewer than one out of twenty trips were by rail. The private automobile accounted for at least three-quarters of trips made by station-area residents for all trip purposes.

Table 4.17

Modal Splits for Different Trip Purposes of Station-Area Residents

	Trip Purpose				
	To Work/ Return Home	Personal Business	Shopping	Social/Recre-ational	Other
Rail Transit	19.0%	10.1%	4.1%	3.7%	5.2%
Bus	1.7	0.8	4.9	3.1	4.1
Drove Car	70.7	76.0	78.0	83.4	77.0
Rode Car	4.3	8.5	7.2	4.9	7.0
Walk	2.4	4.6	4.9	3.1	2.9
Other	1.9	0.0	0.0	1.8	3.8
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Trip Performance, Modal Splits, and Trip Purposes[14]

Rail transit was relied upon most heavily by station-area residents making relatively long trips —on average, around 20 miles one-way[15] (Table 4.18). All other motorized forms of transport were used for trips typically in the 10-12-mile range. In part because of the longer distances covered, rail trips also tended to take the longest — on average, around 45 minutes. Travel times varied more significantly among modal classes than any trip-making variable.[16] For the elapse portion of trips, average speeds by rail transit matched those of the private automobile; bus travel, however, was markedly slower than other motorized modes.

Table 4.18

Comparison of Trip Lengths, Times, and Speeds Among Modes, for Surveyed Station-Area Residents

	Rail Transit	Bus	Drove Car	Rode Car	Walk	Other	F-Statistic	Sig.
Trip Length (miles)								
Average	19.9	11.0	11.5	11.6	2.1	8.5	39.1	.000
(Std. Dev.)	(11.2)	(10.2)	(10.4)	(12.6)	(6.3)	(11.8)		
Trip Time (mins.)								
Average	44.5	38.8	25.6	25.1	20.3	26.4	65.0	.000
(Std. Dev.)	(16.1)	(23.3)	(17.1)	(17.2)	(18.8)	(17.4)		
Trip Speed (mph)								
Average	26.0	15.6	26.4	25.0	4.2	19.0	22.7	.000
(Std. Dev.)	(12.6)	(12.0)	(16.6)	(19.8)	(6.1)	(14.6)		

Trip performance also varied significantly by trip purposes (Table 4.19). Work trips were the longest but also the fastest. In contrast, shop trips were the shortest and the slowest.

Influence of Workplace Transportation Policies

Several transportation policy variables appear to have a strong influence on the modal splits for work trips made by station-area residents (Table 4.20). Among workers residing near a rail station who received transit allowances, 30.8 percent commuted by rail transit; among those without allowances, only 12.5 percent did. Having access to a midday car also appeared to induce some station-area residents to commute by rail transit. By far the strongest influence was parking policies —42 percent of station-area residents who paid for parking commuted via rail transit, compared to only 4.5 percent who received free parking.

Table 4.19

Comparison of Trip Lengths, Times, and Speeds Among Trip Purposes, for Surveyed Station-Area Residents

	To Work/ Return Home	Personal Business	Shop-ping	Social/ Recrea-tional	Other	F-Statistic	Sig.
Trip Length (miles)							
Average	13.7	9.4	6.4	11.5	8.7	14.9	.000
(Std. Dev.)	(11.4)	(9.3)	(7.8)	(11.6)	(9.4)		
Trip Time (mins.)							
Average	29.3	27.5	26.9	26.2	23.1	5.5	.000
(Std. Dev.)	(18.2)	(19.7)	(18.3)	(19.0)	(17.0)		
Trip Speed							
Average	27.0	21.6	18.9	26.2	21.8	8.9	.000
(Std. Dev.)	(16.4)	(14.0)	(16.5)	(20.2)	(14.2)		

Table 4.20

Influence of Workplace Transportation Policies on Modal Splits of Station-Area Residents

Percent	Staggered Work Hours Available		Flexible Work Hours Available		Received Transit Allowance		Have Midday Access to Company Car		Provided Free Parking	
of Trips by:	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Rail Transit	14.4	15.1	17.8	12.4	30.8	12.5	20.6	14.1	4.5	42.0
Drove Car	74.7	76.7	75.1	77.7	58.4	79.5	75.0	76.8	87.6	47.3
Other	10.9	8.2	7.1	9.9	10.8	8.0	4.6	9.1	7.9	10.7
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

In general, modified work schedules, like staggered work hours, were weakly associated with modal splits. There was only a slight tendency for station-area residents with flexible work schedules to favor rail commuting.

Influence of Trip Destination

One of the strongest determinants of whether station-area residents used rail transit was their destination. If they were headed to a large downtown— where parking is usually expensive, connecting highways are often congested, and rail services are the best— station-area residents were likely to choose transit. For trips to smaller downtowns and regional subcenters, rail usage dropped off markedly. And for most other destinations, fewer than one of twenty trips were by rail.

Table 4.21 shows that among those living near BART stations and heading to San Francisco, eight out of ten trips were by BART. This compares with 26.8 percent of trips taken by rail for all destinations. Those living near BART stations and headed to other Bay Area urban centers well-served by BART also relied heavily on rail access. Around 62 percent of station-area residents destined to Berkeley patronized BART. Interestingly, around one-third of those heading to Walnut Creek and Pleasant Hill, both characteristically suburban areas, patronized BART. (This is appreciably above the 5 percent transit modal share that has been measured for all work trips taken to offices near Pleasant Hill and Walnut Creek BART stations [Cervero, 1986].) Table 4.21 also shows that for all destinations other than those listed, fewer than 3 percent of trips taken by station-area residents were by BART. Table A4.6, in the Appendix, shows that destination is an equally important factor in influencing modal splits for work trips. For work trips destined to Oakland or Walnut Creek/Pleasant Hill, around 40 percent of station-area residents patronized BART.

Table 4.21

Modal Splits for All Trips by BART Station-Area Residents, by Destination

Mode	Destination: San Francisco	Oak-Land	Berkeley/ Albany	Walnut Creek/ Pleasant Hill	San Leandro Hayward	Fremont/ Union City	All Other	Share of All Trips
Auto	18.2%	47.8%	28.6%	59.1%	70.0%	80.9%	90.5%	64.4%
Rail	79.8	31.9	61.9	32.6	15.6	13.2	2.6	26.8
Other	2.0	20.3	9.5	8.3	14.4	5.9	6.9	8.8
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Share of All Trips	12.6%	8.8%	2.7%	16.8%	20.4%	17.3%	21.4%	100%

NOTE: The body of this table shows the percent of all trips to each destination made by each mode. The bottom row shows the percent of all trips by station-area residents destined to jurisdictions. The last column shows the percent of all trips by station-area residents by each mode.

While rail usage was far lower for Santa Clara County residents, destination was also an important predictor of mode choice (Table 4.22). For station-area residents traveling within San Jose, nearly 15 percent patronized light rail transit. For those heading to Palo Alto and Stanford University, 8 percent opted for rail travel. However, for those headed to the Silicon Valley, a land of sprawling office parks and abundant free parking, fewer than 3 percent took rail transit. In contrast, 92 percent of station-area residents working in the Silicon Valley drove alone to work. (Percentages were fairly similar for work trips, as shown in Table A4.7, except rail was used relatively less for work trips to Palo Alto and Stanford University.)

Table 4.22

Modal Splits for All Trips by SCCTA Station-Area Residents, by Destination

Modes	Destination: San Jose	Silicon Valley[1]	Palo Alto/ Stanford	All Other	Share of all Trips
Auto	80.6%	94.7%	88.0%	94.7%	89.2%
Rail	14.5	2.4	8.0	0.6	6.7
Other	4.9	2.9	4.0	4.7	4.1
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Share of All Trips	37.3%	44.5%	4.5%	13.7%	100.0%

NOTE: The body of this table shows the percent of all trips to each destination made by each mode. The bottom row shows the percent of all trips by station-area residents destined to jurisdictions. The last column shows the percent of all trips by station-area residents by each mode.

[1]Silicon Valley = Mountain View, Santa Clara, Sunnyvale.

Among residents living near CalTrain stations, rail usage varied considerably depending on whether they were headed to San Francisco or other destinations (Table 4.23). While only around 10 percent of all those living near stations rode CalTrain for all of their trips, among those going to San Francisco, the share was 40 percent. For work trips, 48 percent of trips by station-area residents to San Francisco were by commuter rail (Table A4.8 in the Appendix).

Table 4.23

Modal Splits for All Trips by CalTrain Station-Area Residents, by Destination

Mode	Destination: San Francisco	Brisbane/ SFO	San Mateo/ Redwood City	Palo Alto/ Menlo Park	All Other	Share of all Trips
Auto	56.1%	82.7%	79.7%	61.2%	86.4%	75.7%
Rail	39.0	11.5	3.9	6.1	4.5	9.7
Other	4.9	5.8	16.8	32.7	9.1	14.6
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Share of All Trips	11.5%	14.5%	48.0%	13.7%	12.3%	100.0%

NOTE: The body of this table shows the percent of all trips to each destination made by each mode. The bottom row shows the percent of all trips by station-area residents destined to jurisdictions. The last column shows the percent of all trips by station-area residents by each mode.

In the Sacramento area, trip destination was equally important (Table 4.24). Around 13 percent of station-area residents traveling to Sacramento used light rail, compared to only 3 percent headed to all other destinations. (For work trips, the difference was 18.4 percent versus 2.6 percent; see Table A4.9.) And in the San Diego region, station-area residents were most likely to ride the trolley if their destination was within the city of San Diego; trips along the south line and El Cajon line captured smaller shares of rail trips, and travel to almost any other destination was almost exclusively by some form other than rail transit (Table 4.25). (The city of San Diego was even more dominant in capturing rail trips to work, as shown in Table A4.10.)

Table 4.24

Modal Splits for All Trips by Sacramento RT Station-Area Residents, by Destinations

	Destination		
Mode	Sacramento	All Other	Share of All Trips
Auto	77.0%	95.4%	85.8%
Rail	13.1	3.1	11.5
Other	9.9	1.5	2.7
TOTAL	100.0%	100.0%	100.0%
Share of All Trips	85.2%	14.8%	100.0%

NOTE: The body of this table shows the percent of all trips to each destination made by each mode. The bottom row shows the percent of all trips by station-area residents destined to jurisdictions. The last column shows the percent of all trips by station-area residents by each mode.

Table 4.25

Modal Splits for All Trips by San Diego Trolley Station-Area Residents, by Destination

	Destination				
Modes	San Diego	El Cajon/ La Mesa	Chula Vista/ National City	All Other	Share of all Trips
Auto	80.0%	87.8%	80.3%	98.5%	75.8%
Rail	18.5	8.3	16.7	0.8	11.5
Other	1.5	3.9	3.0	0.7	12.7
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Share of All Trips	36.3%	57.0%	2.7%	4.0%	100.0%

NOTE: The body of this table shows the percent of all trips to each destination made by each mode. The bottom row shows the percent of all trips by station-area residents destined to jurisdictions. The last column shows the percent of all trips by station-area residents by each mode.

5. Mode Choice Models for Rail Trips by Station-Area Residents

This section builds upon the previous one by presenting several models that predict whether station-area residents will patronize rail transit or other modes. Binomial logit models are used to isolate those factors which in combination do the best job of predicting which modes station-area residents will choose. Sensitivity tests are also presented.

Mode Choice Model for Work Trips

Table 4.26 summarizes the logit model for predicting rail transit usage among all surveyed station-area residents for work trips.[17] This was determined to be the "best" model on the grounds that it had the highest pseudo R-Squared statistic and outperformed all others in correctly predicting whether an observed trip was by rail transit.

The **strongest predictor** of rail usage was whether station-area residents had **free parking** at their workplace — rail travel drops off precipitously if station-area residents park free.[18] The **next**

Table 4.26

Binomial Logit Model for Predicting Likelihood of Station-Area Residents Riding Rail Transit, Work Trips and All Systems

	Coefficient	Standard Error	Significance
Free Parking[a]	-2.467	.232	.000
San Francisco Dummy[b]	2.089	.364	.000
East Bay Primary Center Dummy[c]	0.610	.312	.050
Vehicles Available[d]	-0.725	.186	.000
Transit Allowance[e]	0.815	.260	.002
Company Car Access[f]	0.567	.331	.047
Constant	-0.066	.311	.831

Summary Statistics:

Number of cases = 1,913
Chi-Square = -2 (log likelihood ratio) = 262.78, p = .0000
Pseudo-R-Squared = 1- (likelihood ratio) = .618
Percent of all cases correctly predicted by model = 89.9
Percent of rail trip cases correctly predicted by model = 68.4

Notes:

[a]1=Free parking at workplace; 0=paid parking at workplace.
[b]1=San Francisco destination; 0=other destination.
[c]1=Destination is primary East Bay employment center -- Oakland, Berkeley, Walnut Creek, or Pleasant Hill; 0=other destination.
[d]Number of vehicles available for use by household members.
[e]1=Employer helps pay transit expenses; 0=employer provides no assistance.
[f]1=Employer makes available company car; 0=no company car available.

strongest predictor was **destination** —specifically, whether residents worked in San Francisco or the large East Bay employment centers in Oakland, Berkeley, Walnut Creek, and Pleasant Hill. Relative to all other destinations (in the Bay Area as well as in Sacramento and San Diego), station-area residents heading to San Francisco were six times as likely to patronize rail transit and those heading to a major East Bay center were twice as likely to do so, all else being equal.[19]

All other variables included in the model are also consistent with expectations. Rail ridership fell with vehicle availability—each additional vehicle in the household of station-area residents lowered the likelihood of patronizing rail transit by around 10 percent, all other factors being constant.[20] Two workplace policy variables also emerged as important predictors— transit allowance and access to a company car. Holding other factors constant, station-area residents who received some form of transit subsidy from their employer were around 15 percent more likely to patronize rail transit to work as their counterparts who received no assistance. And if they had access to a company car during the midday (in case of emergencies or pressing personal business), they were likewise more likely to commute by rail.

Simulations were also carried out to shed additional light into these relationships. Based on the model output, Figure 4.6 shows the sensitivity of rail transit usage to changes in the three strongest predictors —parking policy, destination, and number of vehicles available.[21] In this figure, the values of the other predictor variables are set to zero— e.g., non-East Bay destination, no transit allowance, and no access to a company car. At one extreme, this graph shows that for someone living near a Bay Area rail station who has no vehicles available, works in San Francisco, and has to pay for parking, there is 88 percent likelihood they will commute via rail transit. On the other hand, if they have three cars available, can park free at their workplace, and are destined anywhere other than San Francisco, there is only about a 1 percent probability that they will opt for rail travel. In the more typical situation where someone had a single vehicle available, the model predicts there is a 24 percent chance they will commute via rail transit if heading to a San Francisco workplace with free parking and a 33 percent chance if going to a non-San Francisco destination with paid parking.

The fact that probabilities drop the sharpest between paid versus free parking underscores the importance of parking policies in influencing mode choice, even among those living within easy walking distance of a station and heading to a destination, like San Francisco, that is well-served by transit.[22] Probabilities change markedly, however, between San Francisco and non-San Francisco destinations as well as free versus paid parking. Figure 4.6 also shows that the probability of rail usage falls the fastest (e.g., steepest slopes) when going from a no-car to a one-car household.

A second simulation was produced wherein the values of the other predictor variables were set to one —workers receive a transit allowance, have access to a company car, and work in a large East Bay urban center (or else San Francisco). Figure 4.7 shows that under these conditions, probabilities consistently rise. Thus, there is a 98 percent probability that a station-area resident without

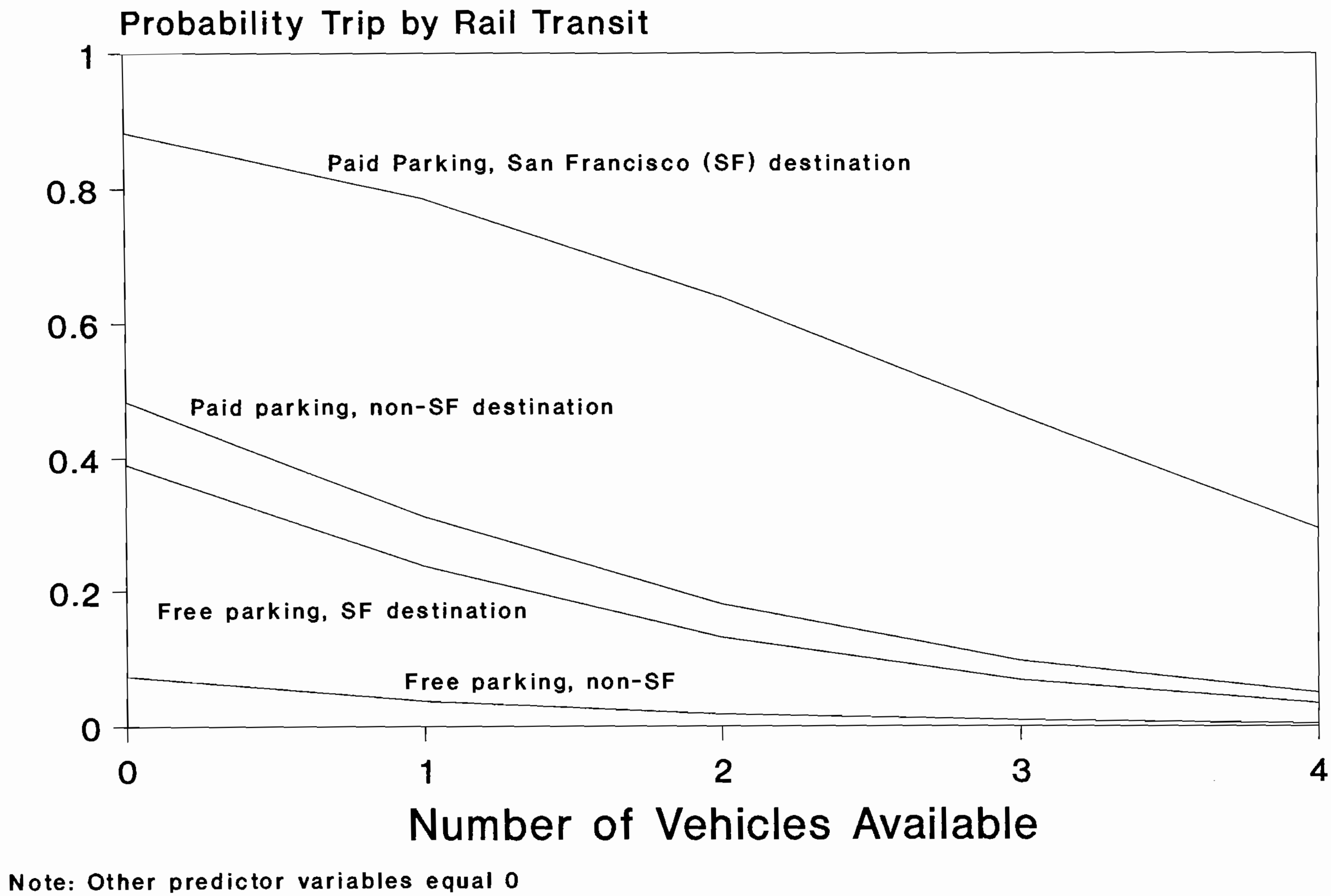
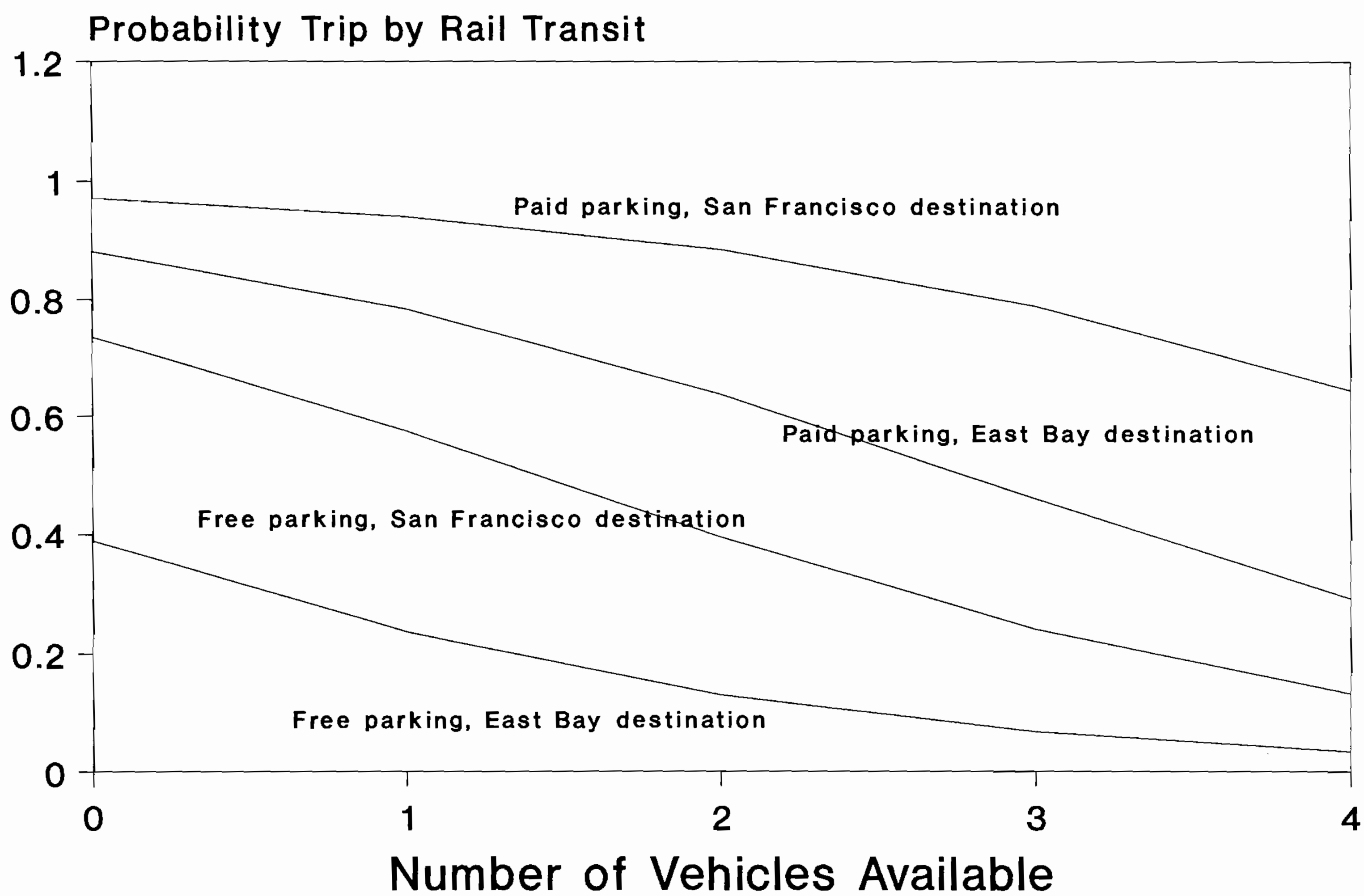


Figure 4-6

Simulation 1:
Sensitivity of Rail Usage to Parking, Destination, and Vehicle Availability



Note: Other predictor variables equal 1

Figure 4-7

Simulation 2:
Sensitivity of Rail Usage to Parking, Destination, and Vehicle Availability

car access who works for a company in San Francisco that charges for parking (and also provides a transit voucher and allows midday usage of a company car) will commute via rail transit. If the same conditions hold except the resident has two vehicles available and works in Oakland instead, the probability of rail usage falls to 64 percent. And if this person were to receive free parking at his or her Oakland workplace, the probability falls to 12 percent. The differential in probabilities between lines in the graph suggests that, all else equal, paid parking increases the likelihood of rail commuting by around 50 percentage points. Additionally, a San Francisco destination increases the odds of rail commuting by 25 to 35 percentage points relative to a large East Bay destination.

Mode Choice Model for Work Trips in the Bay Area Only

Further insights into the importance of trip destination in shaping mode choice were gained by limiting the analysis to just Bay Area destinations (e.g., only residents living near the BART, CalTrain, and SCCTA systems). Table 4.27 reveals that paid parking was again the most important inducement

Table 4.27

Binomial Logit Model for Predicting Likelihood of Station-Area Residents Riding Rail Transit in the Bay Area, Work Trips and BART, CalTrain, and SCCTA Systems

	Coefficient	Standard Error	Significance
Free Parking[a]	-2.501	.368	.000
San Francisco Dummy[b]	3.329	.705	.000
East Bay Primary Center Dummy[c]	1.722	.608	.005
San Jose Dummy[d]	1.440	.622	.021
Bay Area Secondary Center Dummy[e]	-1.179	.294	.000
Vehicle Available[f]	0.862	.344	.012
Constant	-0.522	.692	.451

Summary Statistics:

Number of cases = 976
Chi-Square = -2 (log likelihood ratio) = 240.73, p = .0000
Pseudo-R-Squared = 1- (likelihood ratio) = .360
Percent of all cases correctly predicted by model = 89.8
Percent of rail trip cases correctly predicted by model = 67.56

Notes:

[a] 1=Free parking at workplace; 0=paid parking at workplace.
[b] 1=San Francisco destination; 0=other destination.
[c] 1=Destination is primary East Bay employment center -- Oakland, Berkeley, Walnut Creek, or Pleasant Hill; 0=other destination.
[d] 1=San Jose destination; 0=other destination.
[e] 1=Destination is secondary East Bay employment center -- Fremont, Hayward, San Leandro, Union City, Brisbane, or San Francisco Airport area; 0=other destination.
[f] 1=Number of vehicles available for use by household members.

to riding rail transit among Bay Area residents living near rail stations. The exponentiation of the coefficients on the destination dummy variables indicate the relative importance of different destinations. Relative to all other destinations than the ones listed in the table, station-area residents heading to San Francisco for work are more than 17 times as likely to patronize rail, all else being equal. If the workplace is a large East Bay employment center (Oakland, Berkeley, Walnut Creek, and Pleasant Hill), the odds of rail patronage are five times higher than all other places than the listed destinations, but 70 percent less than for a San Francisco destination. Secondary Bay area employment centers like Fremont, Hayward, San Leandro, Brisbane, and the SFO (airport) area were the third most likely draw for rail transit trips among station-area residents, followed by San Jose employment areas.

Concentrating on solely BART station-area residents, Table 4.28 further substantiates the importance of parking policies and destinations in influencing rail usage. For this subpopulation, having flexible work hours was also found to be an inducement to rail usage, possibly because of the ability to patronize BART under less crowded conditions when more seats are available.

Table 4.28

Binomial Logit Model for Predicting Likelihood of BART Station-Area Residents Riding BART, Work Trips

	Coefficient	Standard Error	Significance
Free Parking[a]	-2.446	.268	.000
San Francisco Dummy[b]	2.857	.431	.000
East Bay Primary Center Dummy[c]	1.594	.383	.000
East Bay Secondary Center Dummy[d]	1.022	.433	.018
Vehicle Available[e]	1.239	.379	.001
Flexible Hours [f]	-0.787	.204	.000
Constant	-0.449	.426	.288

Summary Statistics:

Number of cases = 625
Chi-Square = -2 (log likelihood ratio) = 155.16, p = .0000
Pseudo-R-Squared = 1- (likelihood ratio) = .386
Percent of all cases correctly predicted by model = 85.9
Percent of rail trip cases correctly predicted by model = 63.2

Notes:

[a]1=Free parking at workplace; 0=paid parking at workplace.
[b]1=San Francisco destination; 0=other destination.
[c]1=Destination is primary East Bay employment center -- Oakland, Berkeley, Walnut Creek, or Pleasant Hill; 0=other destination.
[d]1=Destination is secondary East Bay employment center -- Fremont, Hayward, San Leandro, Union City, Brisbane, or San Francisco Airport area; 0=other destination.
[e]Number of vehicles available for use by household members.
[f]1=Has flexible work schedule; 0=does not.

Summary

This and the previous section underscore the importance of two factors in inducing rail usage among station-area residences —*parking policies* and *trip destinations*. From a public policy standpoint, it is clear that if concentrating residential growth around stations is to have substantial payoff, it must be accompanied by programs that pass on true costs to motorists, including parking charges. Additionally, transit-focused housing will not draw many people to transit if workplace destinations are scattered throughout a metropolitan area. For transit-focused housing to reap mobility and environmental dividends, there must also be transit-focused employment centers. This finding speaks to the need of encouraging concentrated employment growth around rail stations, in addition to housing—whether in the form of mixed-use transit villages or separate concentrations. Whether such built forms are brought about through higher motoring and parking charges or stronger regional planning is a difficult political choice.

6. Mode of Access to and from Rail Stations

Information was also compiled on how residents reached their neighborhood rail stations and traveled between their exit station and ultimate destination. Table 4.29 shows that nearly nine out of ten rail users reached the station near their home by foot. The next most common mode of access was to drive a car, particularly in the case of Sacramento RT and SCCTA. Since all of the stations near the surveyed residential projects in these areas have ample park-and-ride facilities, it appears that some residents are induced to use their automobiles to reach rail transit even when they live within a third of a mile of a station. (Of course, some station-area residents might rely on automobiles because of physical impairments and the like.[23]) Such rail trips do little to improve air quality since the emission rates of short automobile trips are fairly high owing to the inefficiency of catalytic converters when engines are cold over the short distance traveled.

Table 4.29

Distribution of Mode of Access from Home to Rail Station, All Trips

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Walk	87.8%	89.3%	73.7%	92.0%	78.8%	95.2%
Drove Car	8.8	8.0	10.5	2.0	21.2	1.2
Ride as Passenger	1.0	0.0	5.3	8.0	0.0	3.6
Bus	0.5	0.9	0.0	0.0	0.0	0.0
Other	1.9	1.8	10.5	0.0	0.0	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Once station-area residents reach their exit station, Table 4.30 shows that, with the exception of the CalTrain systems, most walk to their destination. Bus travel is used as an access mode to a far higher degree at the destination end of the trip. For those traveling to San Francisco, Muni trolleys, cable cars, and light rail vehicles are used as feeder connections as well.

Table 4.30

Distribution of Mode of Access from Rail Station To Workplace, All Trips

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Walk	74.2%	74.5%	76.5%	40.0%	83.3%	84.2%
Bus	20.6	21.8	5.9	55.0	10.0	15.8
Rode as Passenger	2.0	1.8	5.9	5.0	0.0	0.0
Other	3.1	1.9	11.7	0.0	6.7	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Modes of access did vary somewhat depending upon trip purpose. For all trip purposes, walking was the main mode of access. At the home end of the trip, when the automobile was used for reaching a station, it was predominantly for work and personal business trips (Table 4.31). At the

Table 4.31

Influence of Trip Purpose on Mode of Access from Home to Rail Station, All Trips

	Trip Purpose				
	Work	Personal Business	Shopping	Social/Recreational	Other
Walk	87.7%	90.9%	100.0%	100.0%	86.0%
Drove Car	8.0	9.1	0.0	0.0	11.6
Rode as Passenger	1.2	0.0	0.0	0.0	2.4
Other	3.1	0.0	0.0	0.0	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

exit station, walking again predominated for all trip purposes; however, buses were used to reach the final destination for around 20 percent of work and shopping trips (Table 4.32).

Lastly, the average time for accessing the nearest station from one's home was around eight minutes —access time was the shortest for SDT and the longest for BART (Table 4.33). Since trip destinations were not always near exit stations, it took longer, on average over 12 minutes, to reach

Table 4.32

Influence of Trip Purpose on Mode of Access from Rail Station to Workplace, All Trips

	Trip Purpose				
	Work	Personal Business	Shopping	Social/Recre-ational	Other
Walk	73.8%	70.0%	81.2%	93.8%	69.2%
Bus	20.3	2.4	18.8	6.2	28.2
Ride as Passenger	2.2	10.0	0.0	0.0	2.6
Other	3.7	17.6	0.0	0.0	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Table 4.33

Travel Times for Station Access, All Trips

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Travel Time from Home to Rail Station						
Average (minutes)	8.19	9.82	9.39	5.55	6.22	4.77
(Std. Dev.)	(9.23)	(10.87)	(8.58)	(5.32)	(5.08)	(6.98)
Travel Time from Rail Station to Workplace						
Average (minutes)	12.17	13.48	9.44	13.47	8.13	13.2
(Std. Dev.)	(14.30)	(16.85)	(10.70)	(10.27)	(8.78)	(12.87)
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

one's final destination after leaving the rail station. Destinations appeared much closer to Sacramento RT's exit stations than BART's.

7. Changes in Commuting Behavior from Prior Residence

Changes in Mode of Travel

To gain better insights into the benefits associated with Californians residing near rail stations, data were also collected on how station-area residents usually commuted at their prior residence, if that residence was in the same metropolitan area. The most significant environmental and mobility benefits would accrue if substantial numbers of current rail commuters previously drove alone to work (when they resided farther away from a station). Residences near SCCTA stations were omitted from this analysis since Santa Clara County's light rail system was only recently opened, meaning relatively few station-area residents would have been able to commute by rail transit previously. Also, changes in mode of travel were examined only for those whose workplace location did not change between their former and present residence.

Among current rail commuters residing near rail stations, 28.8 percent usually drove alone to work at their previous residence (Table 4.34). These trips represent real societal benefits accruing from the changeover to a cleaner, more energy-efficient form of transportation. A larger share of current rail commuters, however, previously rode rail— 42.5 percent. And around 14 percent previously commuted by bus. Thus, a majority of current rail users previously patronized some form of mass transit when they resided farther away from a rail station. Part of the high incidence of rail usage among station-area residents, then, could be due to the fact they have a higher proclivity to patronize rail transit, whether due to habit, personal taste, or happenstance. Additionally, the decision to rent or buy a home near a rail station might have been influenced by a desire to commute to work by rail transit.

Table 4.34

Comparison of Current Mode for Work Trip and Usual Mode at Prior Residence

Usual Mode for Prior Residence	Current Usual Mode to Work					
	Drive Car	Ride Car	Rail	Bus	Walk	Other
Drove Car	82.0%	65.5%	28.8%	23.5%	40.0%	20.0%
Rode Car	2.0	10.3	3.9	5.9	0.0	0.0
Rail	9.3	6.9	42.5	23.5	13.3	0.0
Bus	2.6	10.3	13.7	41.2	20.0	30.0
Walk	3.2	6.9	4.6	5.9	20.0	15.4
Other	0.9	0.0	6.5	0.0	6.7	34.6
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Among current solo-commuters, 82 percent also drove alone to work every morning from their previous residence. And almost 10 percent previously commuted by rail transit, even though they lived farther from a rail station.

Table 4.35 provides a slightly different perspective by showing how current travel differs from the past. Among those who previously solo-commuted, around three-quarters still solo-commute even though they live closer to a rail station. Just 15.7 percent of the former solo-commuters currently ride rail transit to work; the majority of these individuals, moreover, changed their workplace address, further suggesting the importance of destination as a determinant of rail

Table 4.35

Influence of Prior Commuting Mode on Current Commuting Mode

Current Usual Mode Residence	Usual Mode for Prior Residence: Drove Car	Rode Car	Rail	Bus	Walk	Other
Drive Car	75.5%	38.5%	18.3%	11.4%	41.2%	25.6%
Ride Car	4.8	7.7	1.2	2.9	5.9	5.0
Rail	15.7	46.2	76.8	54.3	41.2	70.0
Bus	1.2	7.6	2.4	17.1	0.0	0.0
Walk	2.0	0.0	1.2	5.7	11.8	0.0
Other	0.8	0.0	0.0	8.6	0.0	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

usage among station-area residents. A much larger share of former ride-sharers, however, have switched to rail commuting—46.2 percent.

Changes in Commute Distance and Time

Among those changing residences within the same metropolitan area (but retaining the same workplace), average commute distances and travel times increased once they moved near a rail station (Table 4.36). Increases in commute time could be due to more transit commuting. Increased

Table 4.36

Comparison of Former Distance and Time Between Prior and Present Residence

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Prior Commute Distance (Miles)						
Average	13.54	16.58	14.08	15.27	9.96	9.26
(Std. Dev.)	(12.34)	(14.78)	(13.89)	(9.66)	(7.08)	(6.08)
Current Commute Distance (Miles)[1]						
Average	14.54.	20.42	12.43	16.90	7.67	11.42
(Std. Dev.)	(13.24)	(15.96)	(13.10)	(11.85)	(4.89)	(6.05)
Prior Commute Time (Min.)						
Average	29.8	36.5	32.9	29.0	21.6	19.6
(Std. Dev.)	(22.1)	(24.9)	(26.2)	(16.4)	(11.69)	(12.90)
Current Commute Time (Min.)[1]						
Average	36.7	53.4	26.4	36.2	23.8	29.3
(Std. Dev.)	(52.2)	(80.8)	(21.1)	(17.9)	(19.3)	(14.6)

[1]These statistics differ from those in Table 4.7 because they are just for work trips and for subpopulations whose residences changed within the same metropolitan area yet their workplaces remained the same.

distances could reflect the decision of some residences to trade-off longer commutes for residing in a neighborhood with good rail transit access and perhaps more affordable housing. These relationships were not uniform, however— in the cases of SCCTA and Sacramento RT, average commute distances and times fell following the move to a station area.

8. Conclusion

The analyses in this chapter reveal the importance of parking policies and the built environment in shaping the travel choices of those living near California's rail stations. Station-area residents are anywhere from five to seven times more likely to travel via rail transit than someone else living within the same community or region. If they work in a major urban center served by rail transit and face daily parking expenses, the likelihood of commuting by rail increases markedly— as high as 90 to 98 percent, depending on whether incentives like employer-paid transit allowances are offered. If, on the other hand, they work in a suburban office park not served by rail but well endowed with free parking, the odds of commuting by rail falls to nearly zero. This chapter further revealed that most rail commuters access stations by foot, which bodes well for transit-based housing from an air quality standpoint. Also, around 28 percent of station-area residents who currently commute by rail previously drove alone to work when they resided elsewhere within the same metropolitan area. Larger shares, however, previously commuted by some form of mass transit, which suggests that the choice to move to a residence near a rail station might have been influenced by a desire to commute by rail transit.

Clearly, if transit-based housing initiatives are to yield significant environmental and mobility benefits, they must be accompanied by other land-use measures which attract employment growth to rail stations as well as transportation demand management programs, like mandatory parking charges. In short, for transit-based housing to win over many former motorists, the metropolitan structures of regions will need to more closely resemble those of places like greater Stockholm and Toronto —both of which have high shares of rail commuting and significant concentrations of population and employment within walking distances of rail stations. Such built forms are like "pearls on a string," with each pearl representing a residential, employment, or mixed-use center, stringed together by subways. Market-rate parking charges are also prevalent in these and other large metropolises with high levels of rail usage.

Whether more clustered development is socially desirable is a bigger question that cannot be answered from this research. And if it is, whether market-based measures like road pricing or more centralized planning initiatives would be the best means of achieving a transit-supportive urban form is largely a political decision. What can be said from this research is that for transit-based housing to yield significant benefits, there must also be large concentrations of employment near rail stations and programs which pass on true costs to motorists and parkers.

Notes

[1]What was considered a "main trip" was up to each respondents' own interpretation. Also, trip data were requested for the prior day in order to reduce selection bias and to provide a full-day perspective on travel behavior. If the previous day was a Saturday or Sunday, respondents were asked to provide travel data for the last weekday they worked. See the survey in Appendix A.

[2]All of the statistics for the three metropolitan areas presented in this chapter were computed from Summary Tape File 3A for California, provided by the 1990 U.S. Bureau of Census.

[3]Vehicles were defined as autos, pickups, and vans; motorcycles were excluded in the definition of vehicles.

[4]This totaled 1,420 —893 primary respondents (the person filling out the survey, which in most cases represented the household's primary wage-earner) and 527 secondary respondents (identified as a second adult in the household).

[5]Respondents represent all adults for whom travel data were provided in the survey returns.

[6]These percentages, of course, reflect the ethnic compositions of station areas surveyed. The relatively high shares of whites partly reflects the fact that the majority of station areas survyed could be characterized as suburban.

[7]The weighted-average ethnic composition for the three metropolitan areas in 1990 was: African Americans —7.8 percent; Asian Americans —12.6 percent; Hispanic —4.9 percent; White —71.7 percent; and Other —3.0 percent.

[8]The 1990 weighted-average breakdown for the three metropolitan areas was: managers/professionals — 35.1 percent; Clerical/Accounting —16.3 percent; Sales/Services —21.5 percent; and Other —27.1 percent.

[9]Other is defined as craftsman, laborer, and all other occupations besides those listed in Table 4.3.

[10]All 1990 journey-to-work census statistics for the Bay Area were obtained from the Metropolitan Transportation Commission (1993). For other areas, data were compiled from STF-1 of the U.S. Bureau of Census. Statistics are for all work trips made by all modes, including walking and bicycling; they exclude workers who work at home, however.

[11]Twice as many residents in these three counties —10.1 percent —commuted to work using all forms of mass transit, including bus, railroad, streetcar, ferry, and cablecar. In the case of San Francisco, 34.9 percent of 1990 commute trips made by its residents were by some form of mass transit.

[12]All modes of transit (which in Santa Clara County's case was predominately bus) are used since the SCCTA light rail system did not begin operations until 1991, one year after the census surveys were conducted.

[13]These statistics are for all transit modes, including bus. Source: U.S. Bureau of Census, Summary Tape File 3A.

[14]Unlike the other sub-sections, transportation mode functions as the independent variables in this sub-section and all other variables presented are influenced by transportation mode.

[15]This statistic seems rather high given the fact that the average length of work trips nationwide was around 11.9 miles in 1990 (Pisarski 1992). The Bay Area averages slightly longer trips than the national average because of the presence of a large water body in the center of the metropolis. Still, the inflated trip length statistic suggests that some of the respondents might have recorded two-way trip lengths, despite the fact that one-way lengths were expressly requested. Any biasing effects, however, were likely comparable across subpopulations and modal classes, meaning the relative differences shown in Table 4.18 probably still hold.

[16]The F-statistic is based on an Analysis of Variance comparison of trip times among modal classes.

[17]The dependent variable, mode of travel, was coded 1 for rail transit trips and 0 for all other modes combined. Thus a simple binary analysis of mode choice was carried out. Also, models were only predicted for work trips (which made up the majority of all trips); however, the models estimated for all trip purposes were almost identical to the work trip models and are thus not presented.

[18]This is reflected by the high coefficient for the "Free Parking" variable relative to the other (0-1 coded) dummy variables. Also, the partial correlation between "Free Parking" and "Mode Choice" was -0.365, which was 90 percent higher than the next highest partial correlation of 0.193 between the San Francisco destination dummy variable and mode choice.

[19]Only this trichotomous breakdown of destinations —San Franciso versus large East Bay centers versus all other destinations —was statistically significant in terms of dummy variables.

[20]This should be interpreted as increasing a probability by nearly 50 percent. Thus, if the model predicts a probability of 0.20 that someone will ride rail transit if they have a single vehicle available, if they were to suddenly have two vehicles available, their probability, according to the model, would fall to 0.18.

[21]This is an Analysis of Covariance, where vehicle availability functions as the covariate and the other variables as the treatment variables.

[22]Another way of showing this is that from the top line of the graph (paid parking, San Francisco destination), the free parking situation (reflected by the third line from the top) has lower probabilities than the non-San Francisco situation (reflected by the second line from the top).

[23]Additionally, in some areas, residents have been known to travel outbound to a terminal station in order to increase the likelihood of obtaining a seat. Such behavior has been observed among residents of Walnut Creek and Lafayette who travel to Pleasant Hill or Concord to catch BART in the morning because seats are often taken by the time inbound trains reach stations in these cities.

Chapter Five

Travel Characteristics of Californians Working Near Urban Rail Transit Stations

1. Introduction

This chapter complements the previous one by analyzing the travel behavior of over 1,400 employees at the 18 surveyed workplaces located near rail stations. Profiles of the sociodemographic characteristics of workers are drawn. A logit model is then built to isolate those factors most strongly associated with rail usage. In addition, the modes of access to and from offices near rail transit stations are studied. Finally, midday trips made by station-area office and factory workers are examined to study their relationship to commute trips and their modal compositions.

2. Background: Household and Demographics Characteristics

The sample of workers surveyed in this study differs from a general cross-section of workers in the regions studied. To begin with, the average household among respondents was larger than the weighted average for the three metropolitan areas (San Francisco-Oakland-San Jose CSMA; Sacramento MSA; San Diego MSA): 2.81 persons per household in the survey compared to 2.71 for the three regions. The figure for the sites served by the San Diego Trolley (3.26) was considerably higher than the weighted average, while the San Diego MSA average was exactly equal to the sample average, 2.81 (Table 5.1).

Table 5.1

Station-Area Worker Household Characteristics

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Household Size						
Average	2.81	2.73	2.7	2.65	2.78	3.26
(Std. Dev.)	(1.42)	(1.27)	(1.41)	(1.28)	(1.33)	(1.75)
No. of Vehicles Available						
Average	2.08	2.06	2.11	2.07	2.12	1.92
(Std. Dev.)	(0.95)	(0.94)	(0.99)	(0.95)	(0.99)	(0.82)

The average number of vehicles available to station-area workers was 2.08, which is considerably above the weighted average of 1.73 for the three regions. The ratio of vehicles to persons in the household, 0.95, is also significantly higher than the weighted average for the three regions (0.64).

This indicates workers near rail stations had both a higher absolute level of auto ownership and more vehicles per family member.

The typical surveyed office worker was, on average, a female in her mid-to-late thirties (Table 5.2). San Diego Trolley stations had a particularly high share of surveyed office workers who were female, while CalTrain had nearly a 50-50 gender split.

Table 5.2

Station-Area Worker Sociodemographic Characteristics

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Age						
Average	37.3	36.3	35.9	36.81	38.8	37.1
(Std. Dev.)	(9.7)	(10.1)	(10.9)	(8.7)	(9.4)	(9.0)
Percent Female	62.9	65.3	56.2	50.7	64.7	71.7

A relatively high share of respondents worked in managerial or professional occupations and a relatively small share worked in sales and services (Table 5.3). Managers and professionals accounted for 41.7 percent of all workers surveyed, compared to a weighted average of 35.1 percent for the three regions. Sales and service employees accounted for only 5.9 percent of surveyed workers compared to 21.5 percent of the workforce in the three regions[1] In San Diego, over half of surveyed workers were in the "other" category, consisting mainly of laborers and factory workers.

Table 5.3

Station-Area Worker Employment Characteristics

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Occupations - Percent						
Manager/Professional	41.7	38.8	55.1	52.9	40.6	28.6
Clerical/Accounting	35.9	43.7	22.8	33.3	40.2	20.0
Sales/Services	5.9	6.2	12.5	4.9	6.1	1.1
Other	16.5	11.4	9.6	8.8	13.1	50.3
Annual Salary - Percent						
$0 - $20,000	15.3	13.0	12.8	6.0	10.2	44.8
$20,000 - $40,000	44.9	47.6	42.1	40.8	52.8	25.7
$40,000 - $60,000	23.9	24.3	23.3	20.9	29.8	12.0
$60,000 - $80,000	8.3	8.0	10.5	16.0	5.6	6.0
> $80,000	7.6	7.0	11.3	16.4	1.5	11.5

The median annual salary category for station-area workers for all five systems was $20,000 to $40,000. For the San Diego Trolley, 44.8 percent earned $20,000 or less— reflecting the large shares of semi-skilled workers and part-time military personnel who work at the businesses and light manufacturing plants that were surveyed on the south line.

3. Trip Characteristics of Station-Area Workers

Modal Splits for Work Trips

Over 80 percent of the respondents reached their workplace by automobile, while 8.8 percent commuted by rail, 3.9 percent by bus, 1.8 percent by walking, and 2.2 percent by other modes (including bike and taxi).[2] Among automobile commuters, 68 percent drove alone, 10 percent drove a carpool, and 4.6 percent rode in a carpool or vanpool. Among those working near a BART station, 68.3 percent drove alone and 17.1 percent commuted by rail. This is in contrast to the average rail commuter share for the counties served by BART— Alameda, Contra Costa, and San Francisco Counties[3] —of 5 percent. It is more than twice the share of work trips by rail by those working near SCCTA light rail stations (8 percent), and over five times higher than the rail share for sites located near the San Diego Trolley (3.2 percent) (Table 5.4).

Table 5.4

Mode Splits For Station-Area Workers

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Percent of trips by:						
Drive Car	68.0	68.3	79.6	73.2	67.0	55.8
Drive w/Others	10.6	6.3	7.3	8.3	13.6	17.4
Ride in Car	4.6	2.0	5.1	2.0	5.0	12.1
Rail	8.8	17.1	8.0	3.9	6.3	3.2
Bus	3.9	3.4	0.0	1.0	5.4	7.4
Walk	1.8	1.7	0.0	3.4	0.8	4.2
Bike	1.5	0.2	0.0	7.3	1.0	0.0
Other	0.7	1.0	0.0	1.0	0.8	0.0
No. of Cases	1,421	410	137	205	479	190

On average, people working near rail stations in California were about 2.7 times more likely to travel to work by rail than other commuters in the same metropolitan area.[4] In the case of BART, there is nearly three-and-a-half times the expected ridership by people working near the rail system. The survey demonstrates that there are region-to-region differences.

Trip Lengths, Times, and Speeds

Among those working near California rail stations, the average trip to work was 14.7 miles (Table 5.5). The commute averaged 32.2 minutes at a speed of 27.9 mph, with a high degree of variation. The highest average speed was for those who drove alone to work: 30.3 mph. On average, those commuting by rail traveled at 22.4 mph and by bus at 20.8 mph, both including time to access transit stops.

Table 5.5

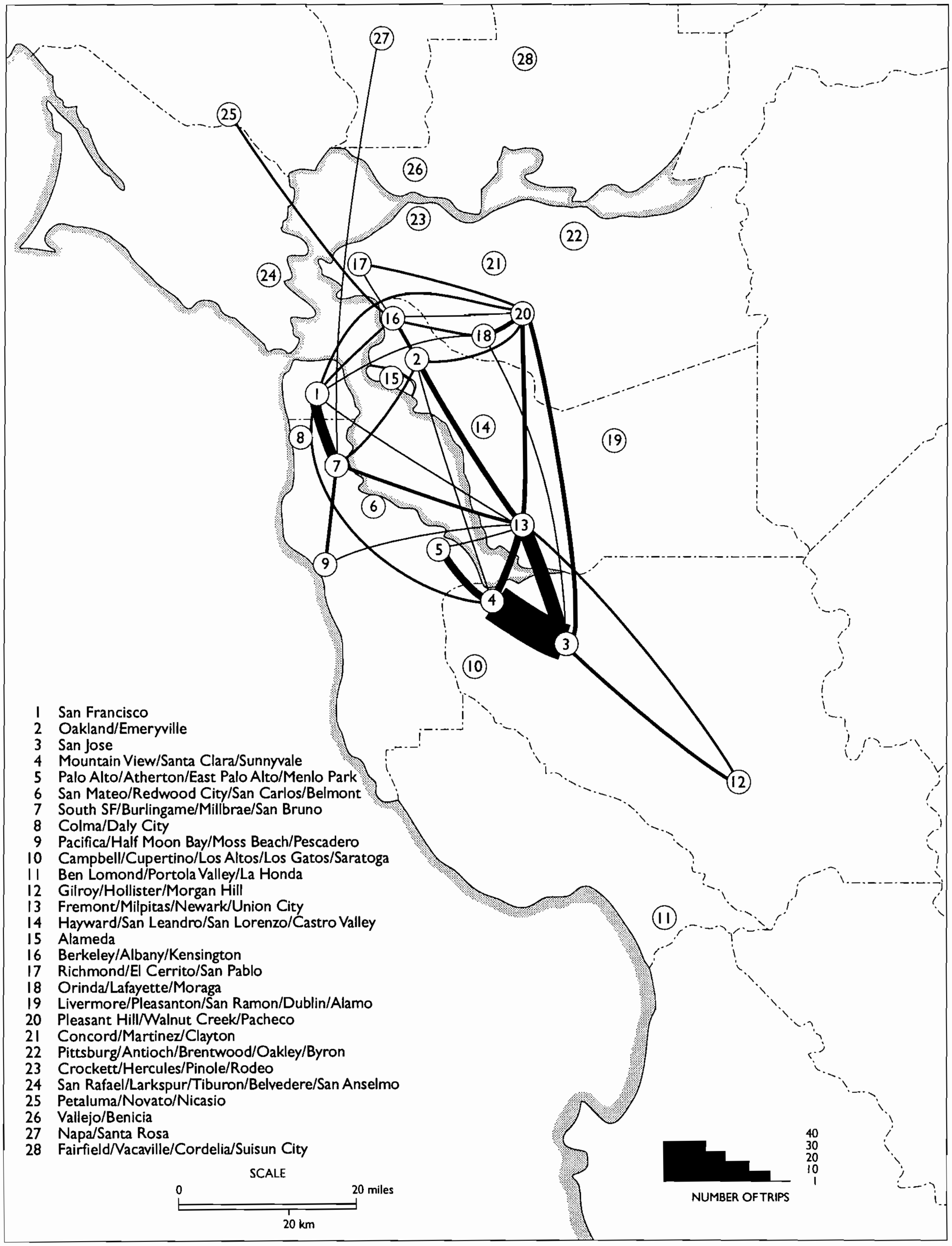
Trip Lengths, Times, and Speeds for all Trips by Station-Area Workers

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Trip Length (miles)						
Average	14.7	17.0	16.3	12.3	14.8	11.9
(Std. Dev.)	(12.6)	(14.6)	(15.8)	(11.4)	(10.8)	(10.1)
Trip Time (minutes)						
Average	32.4	34.6	35.3	28.2	31.8	36.0
(Std. Dev.)	(22.7)	(22.8)	(21.3)	(20.9)	(21.7)	(23.2)
Trip Speed (mph)						
Average	27.9	28.8	29.0	25.2	28.4	26.9
(Std. Dev.)	(20.4)	(22.1)	(34.4)	(15.6)	(16.9)	(15.2)

Trips by rail were typically longer than those by other modes: 21.9 miles compared to 14.8 miles for drive-alone trips (13.2 miles for trips by bus). As a result of longer distances and lower speeds, trips by rail took longer than by other modes: 55.7 minutes compared to 29 minutes for drive alone-trips. Rail trips were 26 percent slower than door-to-door auto trips. This is considerably less dramatic than the difference reported in Chapter Four. In part, this reflects the higher degree of park-and-ride access for home-to-rail trips among persons who work but may not live near rail, compared to those persons who live but do not necessarily work near rail and may have to transfer to bus or walk for a considerable distance to reach their workplace.

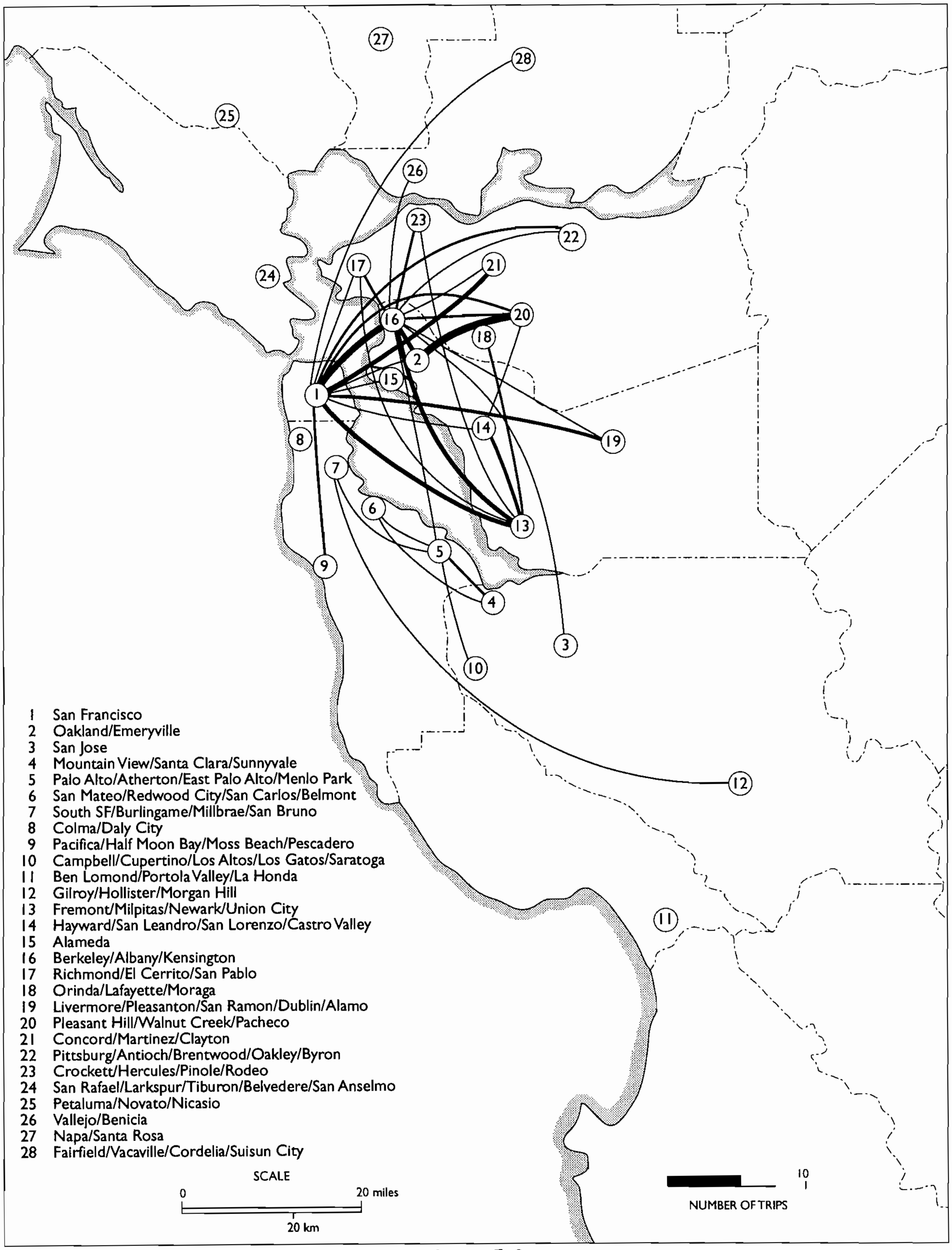
Spatial Patterns

Maps 5.1 and 5.2 compare the city-by-city origin-destination patterns of work trips made by station-area employees by rail transit versus automobile in the Bay Area. The high volume of auto traffic between Fremont, San Jose, and Silicon Valley (Map 5.1) is explained by the large numbers of employees in high-technology fields who work near BART and SCCTA stations and who live in pockets of relatively affordable housing in the South Bay. By contrast, there is rela-



Map 5.1

Origin-Destination Patterns for Automobile Trips by Sampled Station-Area Workers in the San Francisco Bay Area, Work Trips



Map 5.2

Origin-Destination Patterns for Rail
Trips by Sampled Station-Area Workers in the San Francisco Bay Area, Work Trips

tively little auto commuting across the Bay Bridge to BART-served workplaces, evidently because BART commuting is advantageous for such travel, as suggested in Map 5.2.

Map 5.2 indicates the heaviest corridors of rail commuting to workplaces near Bay Area rail stations are: (1) central Contra Costa County to San Francisco; (2) Fremont to San Francisco and Berkeley; and (3) Walnut Creek to Oakland. By contrast, rail traffic between cities served only by SCCTA and CalTrain seem meager.

Commute Trip Cost Characteristics

On average, station-area workers who commuted by rail transit paid $3 in round-trip fares, though there was considerable variation, ranging from $1.77 for RT users to $3.79 for CalTrain commuters (Table 5.6). Tolls were incurred mainly by workers driving across the San Francisco-Oakland Bay Bridge. For the most part, those working near rail stations enjoyed free parking or paid nominal amounts per day.

Table 5.6

Station-Area Worker Commute Trip Cost Characteristics

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Roundtrip Fares						
Average ($)	2.99	3.31	2.67	3.79	1.77	n/a
(Std. Dev.)	(1.60)	(1.58)	(2.54)	(1.64)	(0.58)	
Parking Cost						
Average ($)	0.25	0.11	n/a	n/a	0.50	n/a
(Std. Dev.)	(0.49)	(0.30)			(0.87)	
Tolls						
Average ($)	0.94	1.18	0.62	n/a	n/a	n/a
(Std. Dev.)	(1.53)	(1.64)	(0.87)			

Workplace Transportation Policies

About half the workers at sites near CalTrain and Sacramento RT stations said their employers offer flexible worktime privileges (Table 5.7). San Diego Trolley workers cited a much lower incidence — 12.4 percent — far below the mean incidence (42.9 percent). Sacramento had the highest incidence of staggered work hours— 26.3 percent, well above the mean of 16.6 percent. Nearly a quarter of the workers at sites near SCCTA and CalTrain had access to a company car for midday trips, compared to under 9 percent of BART area workers and less than 5 percent of SDT area workers.

Table 5.7

Workplace Transportation Policies

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Percent with flextime privileges	42.9	38.5	42.5	53.4	53.1	12.4
Percent with staggered workhours	16.6	11.3	16.4	13.2	26.3	5.2
Percent provided a car for midday use	14.7	8.8	23.1	24.7	16.4	4.6
Percent with transit allowance	14.2	9.6	3.0	7.4	21.1	23.5
Percent with free parking	76.2	80.4	78.4	90.9	76.1	47.7
Monthly Parking Costs						
Average ($)	71.13	63.00	n/a	n/a	53.94	88.94
(Std. Dev.)	(26.28)	(11.31)			(27.59)	(16.04)

San Diego workers reported the highest incidence of employers paying for transit expenses: 23.5 percent. San Diego workers also had the lowest incidence of employer-provided free parking (47.7 percent compared to the 76.2 percent average). Despite these two inducements to patronize rail, sites located near the San Diego Trolley attracted the smallest share of trips by rail among the sites surveyed.

4. Factors Associated with Rail Ridership

As a counterpart to the analysis in Chapter Four, this section explores how various demographic, trip-making, and travel cost characteristics of station-area workers are associated with rail usage. This analysis provides background for estimating mode-choice models for station-area workers.

Influence of Household Characteristics

Table 5.8 shows that workers from large households are more prone to auto commuting, whereas rail use declined as household size increased. More strongly related to modal choice is the

Table 5.8

Influence of Household Size on Modal Splits of Station-Area Employees

	Household Size			
Modes	1	2	3	4 or more
Drive Car	68.7%	65.3	71.2	68.6
Drive w/Others	5.7	10.6	11.3	12.9
Ride in Car	0.5	5.2	2.6	7.5
Rail	12.8	9.2	9.9	5.8
Bus	4.3	5.2	1.8	3.8
Walk	4.7	1.8	0.4	0.9
Other	3.3	2.8	2.9	0.4
TOTAL	100.0%	100.0%	100.0%	100.0%

number of vehicles available to the worker— 62 percent of those from households without a car commuted by rail transit, compared to just 5 percent of workers in 3+ car households (Table 5.9).

Table 5.9

Influence of Vehicle Availability on Modal Splits of Station-Area Employees

	Number of Vehicles Available For Use by Household Members			
Modes	0	1	2	3 or more
Drive Car	0.0%	55.2%	71.3%	76.9%
Drive w/Others	6.3	12.6	10.4	9.2
Ride in Car	0.0	4.9	4.5	4.9
Rail	62.5	13.5	7.0	5.4
Bus	25.0	5.7	3.6	1.9
Walk	6.3	4.9	0.7	0.8
Other	0.0	3.2	2.5	0.8
TOTAL	100.0%	100.0%	100.0%	100.0%

Influence of Sociodemographic Factors

Although male station-area workers showed a higher propensity to travel by rail than their female counterparts, differences were not significant (Table 5.10). Nor did age have any discernible effect on rail ridership —for those over 20 years of age, between 8 and 10 percent commuted by rail transit (Table 5.11). No strong patterns emerged between either occupation or salary and workers' commuting modes —clerical/accounting workers and middle-income workers averaged slightly higher rates of rail commuting (Tables 5.12 and 5.13). Low-income workers had a much stronger tendency to rideshare relative to higher-income workers.

Table 5.10

Influence of Gender on Modal Splits of Station-Area Employees

	Gender	
	Female	Male
Drive Car	68.8%	66.7%
Drive w/Others	11.3	9.4
Ride in Car	5.9	2.7
Rail	7.8	10.7
Bus	3.8	4.0
Walk	1.6	2.1
Other	0.9	4.4
TOTAL	100.0%	100.0%

Table 5.11

Influence of Age on Modal Splits of Station-Area Employees

Mode	Age 0-20	21-30	31-40	41-50	50-70	> 70
Drive Car	95.2%	69.6%	67.8%	64.7%	67.0%	73.9%
Drive w/Others	4.8	10.3	10.5	12.1	11.8	2.2
Ride in Car	0.0	5.0	4.2	4.6	5.5	6.5
Rail	0.0	8.4	8.2	10.0	10.2	8.7
Bus	0.0	3.3	4.0	4.3	4.7	4.3
Walk	0.0	1.7	1.6	2.4	0.8	4.3
Other	0.0	1.7	3.6	1.9	0.0	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5.12

Influence of Occupation on Modal Splits of Station-Area Employees

Modes	Occupations: Manager/ Professional	Clerical/ Accounting	Sales/ Services	Other
Drive Car	83.1%	69.2%	68.1%	59.8%
Drive w/Others	3.6	8.5	11.8	15.5
Ride in Car	1.2	3.1	4.2	10.4
Rail	7.2	10.9	8.4	5.2
Bus	2.4	2.7	5.0	5.2
Walk	0.0	1.7	1.4	3.6
Other	2.4	3.8	1.2	0.4
TOTAL	100.0%	100.0%	100.0%	100.0%

Table 5.13

Influence of Annual Salary on Modal Splits of Station-Area Employees

Modes	Annual Salary: 0-$20,000	$20,000-$40,000	$40,000-$60,000	$60,000-$80,000	>$80,000
Drive Car	63.9%	69.7%	65.3%	67.5%	73.8%
Drive w/Others	12.7	10.6	11.3	11.4	3.9
Ride in Car	8.8	5.2	2.1	0.9	2.9
Rail	7.8	7.2	13.2	10.5	5.8
Bus	4.4	4.3	5.2	0.0	2.9
Walk	2.4	1.8	0.9	4.4	1.0
Other	0.0	1.2	1.8	5.2	9.7
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Influence of Trip Length and Time

As discussed in Chapter Four and suggested in the spatial analysis in this chapter, among station-area workers the propensity to use rail increased with trip length. The average commute by rail was 21.9 miles, longer than trips made by any other mode (Table 5.14). In any metropolitan area, a trip of this length could probably not be made by auto without traveling a substantial portion of the way on the freeway network. The need to do so might be a significant deterrent to automoble travel when there is a viable rail alternative. Even if rail is only used for the line-haul portion of the trip, the park-and-ride alternative may be preferred over a 22-mile door-to-door trip by auto under typical traffic conditions in any of California's metropolitan areas. Table 5.14 also shows that Station-area workers who commuted by rail spent nearly twice as long reaching their workplace, explained partly by the longer average distance and partly by the slower average speed of rail travel.

Table 5.14

Comparison of Trip Lengths, Times, and Speeds Among Modes

	Current Mode						
	Drove Alone	Drove w/ Others	Rode in Car	Rail	Bus	Walk	Other
Trip Length (miles)							
Average	14.8	14.0	15.0	21.9	13.2	0.7	11.8
(Std. Dev.)	(12.9)	(9.8)	(11.0)	(14.6)	(9.7)	(0.6)	(5.4)
Trip Time (minutes)							
Average	29.0	32.7	31.9	55.7	42.8	16.5	17.8
(Std. Dev.)	(20.5)	(23.6)	(20.7)	(21.4)	(20.8)	(12.2)	(13.0)
Trip Speed (mph							
Average	30.3	26.3	28.8	22.4	18.0	2.7	9.3
(Std. Dev.)	(22.7)	(12.6)	(14.8)	(10.0)	(8.9)	(1.5)	(7.0)

Influence of Workplace Transportation Policies

The various transportation policies pursued by employers had conflicting impacts on rail ridership (Table 5.15). Staggered work hours appeared to discourage rail ridership. Only 5.3 percent of workers at firms which staggered work hours commuted by rail, compared to 8.8 percent of workers at firms that did not. The ability to shift one's commute from peak period to off-peak might have made auto commuting more attractive.

Differences were even greater where employees received a travel allowance— they are more than four times as likely to take rail to work. While only around one-half of station-area workers who received transit allowances solo-commuted, if no such allowances were available, nearly 80 percent commuted by themselves. The factor which discouraged rail use the most was the availabil-

Table 5.15

Influence of Workplace Transportation Policies on Modal Splits of Station-Area Employees

	Staggered Work Hours Available		Flexible Work Hours Available		Received Transit Allowance		Provide Free Parking		Have Midday Access to Company Car	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Drove Car	72.8%	75.9%	76.5%	74.3%	53.1%	78.9%	83.1%	50.2%	70.9%	76.0%
Drove w/Others	16.0	10.5	11.1	11.6	12.4	11.1	11.2	12.1	13.2	11.1
Rode in Car	2.4	2.9	1.9	3.5	5.1	2.4	1.9	5.7	2.2	2.9
Rail	5.3	8.8	8.6	8.1	24.3	5.8	3.0	25.6	10.4	7.9
Bus	1.0	0.9	0.6	1.1	4.5	0.3	0.2	3.0	1.1	0.9
Walk	0.5	0.4	0.2	0.6	0.6	0.4	0.1	1.3	0.5	0.4
Other	1.9	0.7	1.1	0.7	0.0	1.0	0.5	2.0	1.6	0.8
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

ity of free parking. Only 3 percent of the workers who received free parking commuted by rail, whereas over one-quarter of those who had to pay to park opted for rail commuting.

Access to a company car seems to have made travel by rail more appealing: 10.4 percent with access commuted by rail compared to 7.9 percent without access. The need to make midday trips away from the workplace does seem to be an important determinant— 11 percent of workers commuted by rail when no midday trips were made, compared to only 6.5 percent when one midday trip was made. The need to make at least one midday trip for company or personal business corresponded to a reduction in commutes by rail from 10.5 percent to 4.1 percent.

Influence of Trip Origin

Persons who live in an area served by the same rail system located near their workplace are slightly more likely to commute by rail. For example, 19.3 percent of those who lived in areas served by BART and who worked near BART stations commuted by BART compared to 12.8 percent of those who worked in similar settings but did not live in BART-served cities (Table 5.16). The highest incidence of BART usage was by Oakland residents who worked near a station— 43 percent.

Of persons working at sites near SCCTA stations, 15.9 percent of those living in San Jose commuted by light rail (Table 5.17). By contrast, none of those surveyed who lived in the Silicon Valley (also served by rail) used the system. Of persons living in cities not served by SCCTA's rail network, only 2.5 percent rode light rail to work.

A smaller proportion of those who live and work in cities served by CalTrain rode CalTrain to work than those who live in cities not served by that system (Table 5.18). At the level of aggregation for which residential data are available, there appears to be no relationship between residential proximity to CalTrain and ridership. A similar result was found for persons working near the San Diego trolley (Table 5.19) and Sacramento RT (Table 5.20).

Table 5.16

Modal Splits for Work Trips by BART Area Workers, by Origin

	Origins Not Served by BART				Origins Served by BART							
	Livermore	Antioch	Others Not Served	Total Not Served	Oakland	Walnut Creek	San Francisco	Hayward	Concord	Others Served by BART	Total Served by BART	Share of work Trips
Drove Car	76.7%	83.3%	98.6%	76.7%	35.7%	72.7%	25.8%	75.9%	70.4%	73.9%	64.4%	68.3
Drove w/Others	9.3	4.2	2.0	4.5	14.3	9.1	6.5	3.4	11.1	5.1	6.9	6.3
Rode Car	2.3	0.0	2.0	1.5	0.0	0.0	3.2	3.4	0.0	2.9	2.2	2.0
Rail	9.3	12.5	20.1	12.8	42.9	9.1	32.3	17.2	18.5	13.8	19.3	17.1
Bus	0.0	0.0	8.0	3.0	3.6	4.5	16.1	0.0	0.0	2.2	3.6	3.4
Walk	0.0	0.0	0.0	0.0	0.0	4.5	9.7	0.0	0.0	2.2	2.5	1.7
Other	2.3	0.0	2.0	1.5	3.6	0.0	6.5	0.0	0.0	0.0	1.1	1.2
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Share of Work Trips	10.5%	5.9%	16.1%	32.5%	6.8%	5.4%	7.6%	7.1%	6.6%	33.7%	67.6%	100.0%

NOTE: The body of this table shows the percent of all trips from each origin made by each mode. The bottom row shows the percent of all trips by station-area workers who resided in each jurisdiction. The last column shows the percent of all trips by station-area workers by each mode.

Table 5.17

Modal Splits for Work Trips by SCCTA Area Workers, by Origin

	Origins Not Served by SCCTA	Origins Served by SCCTA			Share of Work Trips
		Silicon Valley	San Jose	Total Served By SCCTA	
Drove Car	83.3%	76.9%	78.3%	77.9%	79.6%
Drove w/Others	11.9	15.4	1.4	5.3	7.3
Rode Car	4.8	7.7	4.3	5.3	5.1
Rail	0.0	0.0	15.9	11.6	8.0
Bus	0.0	0.0	0.0	0.0	0.0
Walk	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Share of Work Trips	30.7%	19.0%	50.4%	69.3%	100.0%

NOTE: The body of this table shows the percent of all trips from each origin made by each mode. The bottom row shows the percent of all trips by station-area workers who resided in each jurisdiction. The last column shows the percent of all trips by station-area workers by each mode.

Table 5.18

Modal Splits for Work Trips by CalTrain Area Workers, by Origin

	Origins Not Served by CalTrain			Origins Served by CalTrain					
	Cupertino	Others Not Served	Total Not Served	Silicon Valley	Palo Alto	San Mateo	Others Served by CalTrain	Total Served by CalTrain	Share of Work Trips
Drove Car	57.9%	86.7%	75.5%	59.0%	58.8%	92.6%	80.4%	72.4%	73.2%
Drove w/Others	10.5	3.3	6.1	12.8	5.9	0.0	12.5	9.0	8.3
Rode Car	5.3	0.0	2.0	0.0	2.9	0.0	3.6	1.9	2.0
Rail	5.3	3.3	4.1	5.1	2.9	7.4	1.8	3.8	3.9
Bus	5.3	0.0	2.0	0.0	0.0	0.0	1.8	0.6	1.0
Walk	0.0	0.0	0.0	15.4	2.9	0.0	0.0	4.5	3.4
Other	15.8	6.7	10.2	7.7	26.5	0.0	0.0	7.7	8.3
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Share of Work Trips	9.3%	14.6%	23.9%	19.0%	16.6%	13.2%	27.3%	76.1%	100.0%

NOTE: The body of this table shows the percent of all trips from each origin made by each mode. The bottom row shows the percent of all trips by station-area workers who resided in each jurisdiction. The last column shows the percent of all trips by station-area workers by each mode.

Table 5.19

Modal Splits for Work Trips by Sacramento RT Workers, by Origin

	Origins Not Served by Sacramento RT				Origins Served by Sacramento RT	Share of Work Trips
	Auburn	Folsom	Others Not Served	Total Not Served		
Drove Car	64.7%	67.4%	68.8%	67.6%	66.1%	67.0%
Drove w/Others	23.5	14.0	12.5	14.7	12.4	13.6
Rode Car	5.9	5.4	7.3	6.2	3.7	5.0
Rail	5.9	10.9	2.1	6.9	5.5	6.3
Bus	0.0	0.8	9.4	3.9	7.3	5.4
Walk	0.0	0.0	0.0	0.0	1.8	0.8
Other	0.0	1.6	0.0	0.8	3.2	1.8
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Share of Work Trips	7.1%	26.9%	20.0%	54.3%	45.5%	100.0%

NOTE: The body of this table shows the percent of all trips from each origin made by each mode. The bottom row shows the percent of all trips by station-area workers who resided in each jurisdiction. The last column shows the percent of all trips by station-area workers by each mode.

Table 5.20

Modal Splits for Trips by San Diego Trolley Area Workers By Origin

	Total Not Served	Origins Served By San Diego Trolley: Chula Vista	La Masa	San Diego	Total Served by S.D. Trolley	Share of Work Trips
Drove Car	65.0%	43.1%	55.6%	59.8%	54.3%	55.8%
Drove w/Others	5.0	23.5	22.2	15.7	18.5	17.4
Rode Car	0.0	23.5	11.1	8.8	13.6	12.1
Rail	5.0	0.0	11.1	3.9	3.1	3.2
Bus	20.0	3.9	0.0	7.8	6.2	7.4
Walk	5.0	5.9	0.0	3.9	4.3	4.2
Other	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Share of Work Trips	10.5%	26.8%	4.7%	53.7%	85.3%	100.0%

NOTE: The body of this table shows the percent of all trips from each origin made by each mode. The bottom row shows the percent of all trips by station-area workers who resided in each jurisdiction. The last column shows the percent of all trips by station-area workers by each mode.

Another spatial factor influencing ridership is the proximity of the place of work to the nearest rail transit station. Close proximity of an employment site to a rail station corresponds to high levels of rail use: 22 percent of those who worked within 500 feet of a rail station commuted by rail, as opposed to 3.5 percent of those who worked beyond this radius. This relationship between proximity and ridership is discussed further in Chapter Seven.

5. Mode Choice Model for Rail Trips by Station-Area Workers

As in Chapter Four, a binomial logit model was estimated to identify which variables best explained the decision by station-area workers to commute by rail. A model of modest predictive abilities was estimated, one that predicted non-rail commute choices quite accurately but which could not predict rail commutes above 50 percent accuracy. The best predictive model is summarized in Table 5.21.

Based on the model results, two simulations were run to further explore the relationship between station-area employees' rail usage and three of the strongest predictor variables — parking prices, trip origin, and vehicle availability. Figure 5.1 represents the scenario where all other dummy variables (not shown in the graph) are set to zero, and Figure 5.2 is the scenario where other dummies are set to one.[5]

Figure 5.1 shows that if a station-area employee was from a household with one vehicle for every two household members, the likelihood she commuted by rail was 40 percent higher if she

Table 5.21

Binomial Logit Model for Predicting the Likelihood of Station-Area Workers Commuting by Rail Transit, All Systems

	Coefficient	Standard Error	Significance
Vehicles per Person[a]	-3.561	.670	.000
BART City Dummy[b]	2.338	.390	.000
San Jose Dummy[c]	2.301	.580	.000
Free Parking[d]	-1.031	.440	.019
Household Size[e]	-.610	.152	.000
Pay Parking & Allowance[f]	2.394	.434	.000
Commute Distance[g]	.071	.011	.000
Parking per Employee[h]	-.471	.168	.005
Midday Trips[i]	-.720	.261	.006
Close Workplace[j]	2.037	.407	.000
Constant	-.174	1.014	.864

Number of cases = 1,140
Chi-Square = 304.49, p = .0000
Pseudo R-Squared = 0.484
Percent of all cases correctly predicted by the model: 94.3 percent
Percent of rail trip cases correctly predicted by model: 45.6 percent

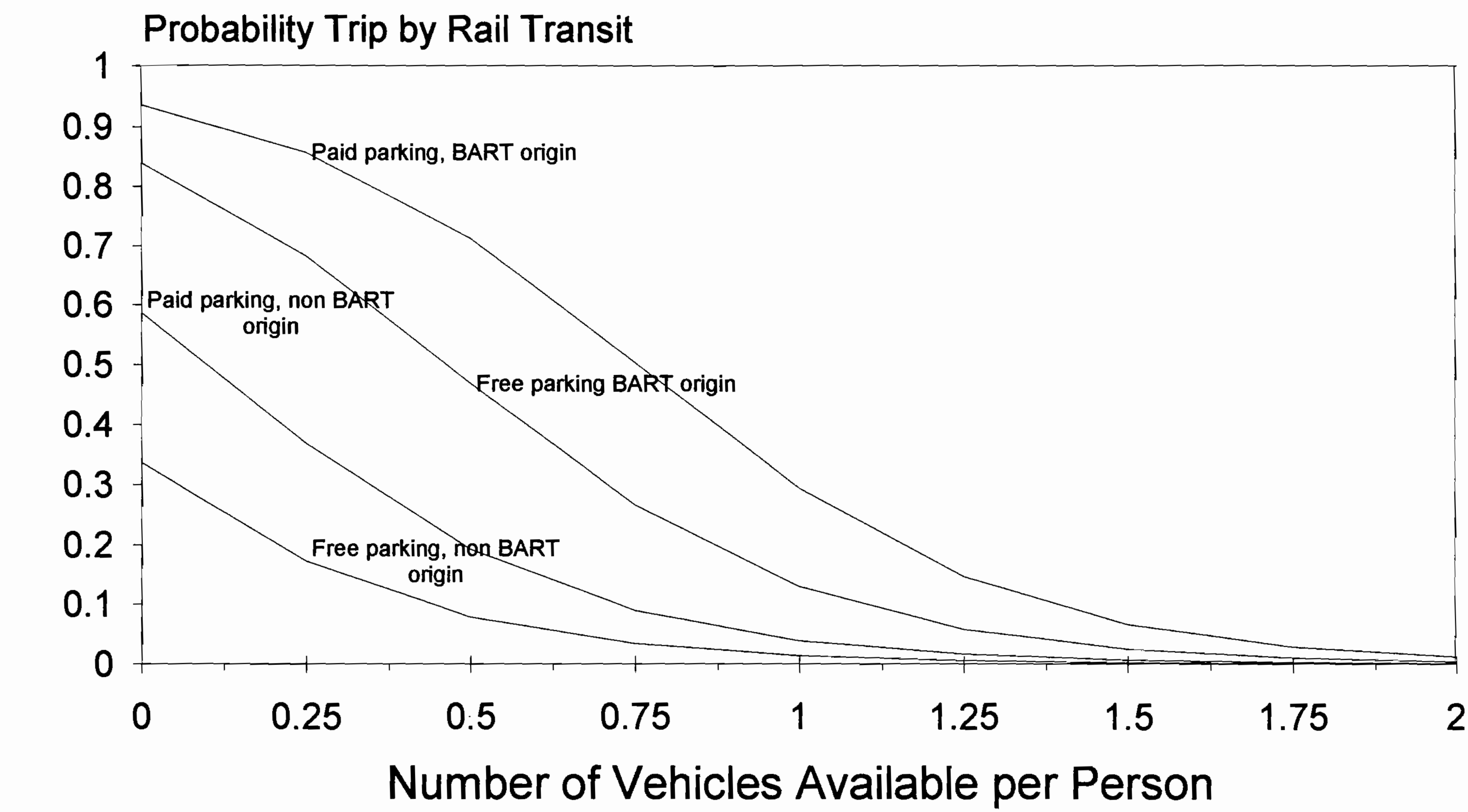
[a]Number of vehicles per person per household.
[b]1 = Origin is a city served by BART; 0 = Origin is a city not served by BART.
[c]1 = Origin is San Jose; 0 = otherwise.
[d]1 = Free parking at workplace; 0 = paid parking at workplace.
[e]Number of people in worker's household.
[f]1 = Parking is not free and employer pays transit allowance; 0 = otherwise.
[g]Distance traveled from home to work, in miles.
[h]Number of parking spaces per employee at workplace.
[i]1 = Number of midday trips made.
[j]1 = Workplace is less than 500 feet from rail station; 0 = otherwise

lived in a city served by BART versus in a city that is not. On the other hand, free parking reduced the probability of rail commuting by 10 to 20 percent for the same employee.

Figure 5.2 suggests that the likelihood a station-area worker who also lives in a rail-served city commutes by rail approaches one when other conditions are favorable— such as paid parking at a workplace that lies within 500 feet of the station and the availability of a transit allowance. Transit subsidies and parking prices are shown to be of equal importance. For instance, if a worker is from a household with one car per person, under the most favorable condition, Figure 5.2 shows there is around a 98 percent chance he will commute via rail. If these same conditions hold except he no longer receives a transit allowance, the probability drops to 78 percent. And if parking becomes free at his workplace, the odds of transit commuting fall to 58 percent.

Overall, these findings reveal the following:

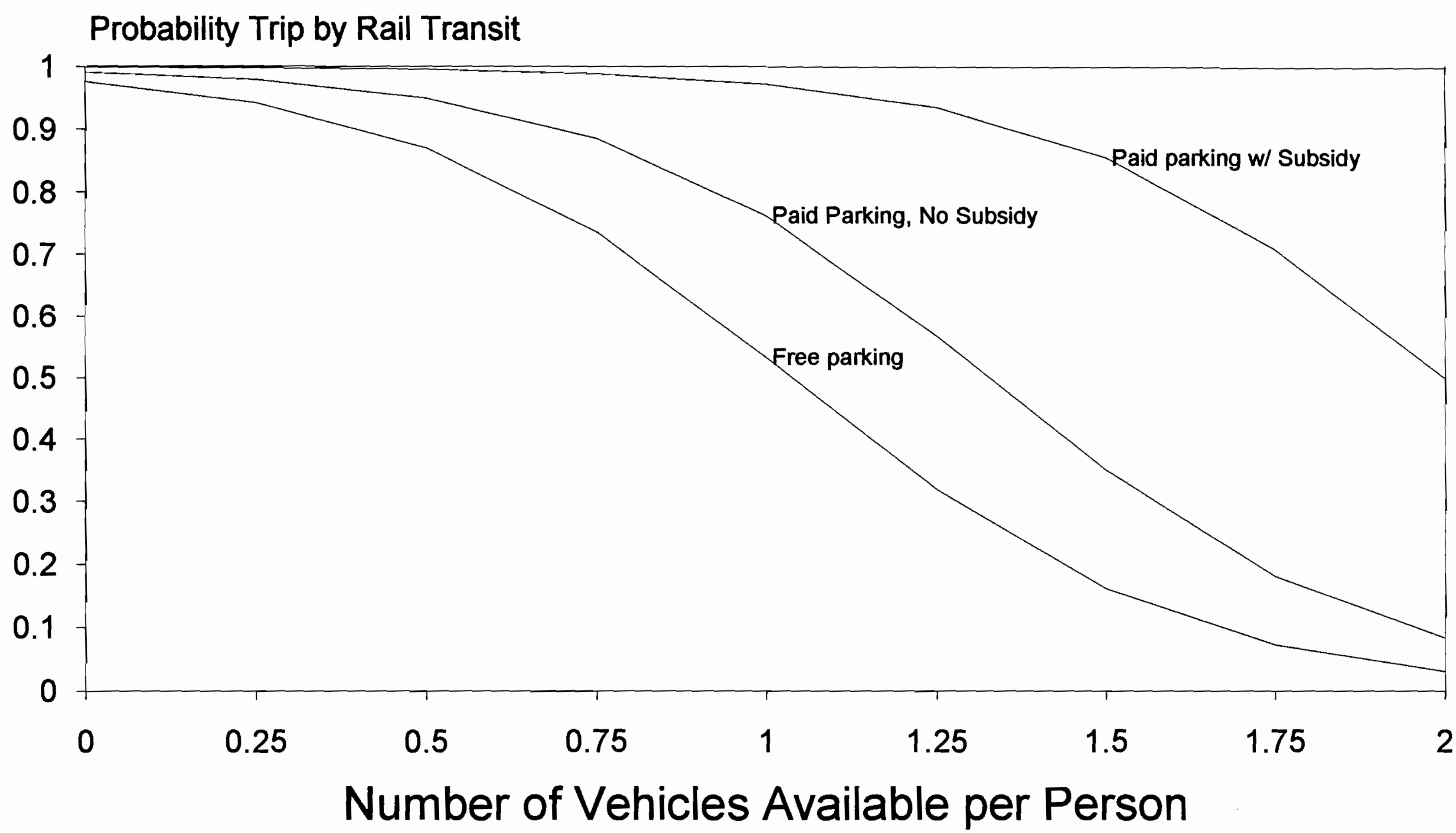
- Vehicle availability, defined in terms of vehicles per household, was the strongest predictor of whether station-area workers commuted by rail.
- Free parking discouraged rail commuting. Paid parking, when combined with an employer-provided travel allowance, encouraged rail commuting. The analy-



Note: Other Predictor variables equal 0 except where illogical

Figure 5.1

Simulation 1: Sensitivity of Rail Ridership to Parking, Origin, and Vehicle Availability



Note: Other predictor variables equal to 1 except where illogical

Figure 5.2

Simulation 2: Sensitivity of Rail Ridership to Parking, Origin, and Vehicle Availability

sis showed that a travel allowance was not significant unless it was combined with the absence of free parking. Free parking, on the other hand, was significant by itself in deterrring rail commuting and encouraging solo commuting.

- Place of origin was also a significant determinant of whether station-area workers commuted by rail. Specifically, trips originating in San Jose or any city served by BART had a much higher chance of being made by rail transit.
- Whether or not parking was free, as the supply (spaces per worker) increased at the workplace, rail commuting fell.
- Rail commuting increased with commute distance.
- The need to make midday trips, on the other hand, discouraged rail commuting among station-area workers.
- Ease of walking made a difference — commuting shares by rail was the highest for workplaces within 500 feet of a rail station entrance.
- Workers from large households were less likely to commute by rail, perhaps in part because carpooling becomes more feasible in larger and multiple-earner households.

Thus, consistent with the findings from Chapter Four, parking policies and the physical environment has a strong bearing on whether station-area workers in California commute by rail transit. From a land-use planning standpoint, greater concentrations of housing near stations, combined with workplaces that are within easy walking distance of stations and are surrounded by mixed uses (to satisfy midday trip-making needs), would substantially increase rail commuting in the state.

Summary

For those working near California rail stations, the chances of commuting by rail increase dramatically if they also live near rail. Thus, consistent with the findings of the previous chapter, both the origin and destination ends of the commute trip need to be in reasonably close proximity to a station for there to be high levels of rail travel. That is, transit-based workplaces require transit-based housing if rail travel is to seriously compete with the private automobile. When combined with parking charges and such incentives as transit vouchers, concentrated development of both employment centers and housing near rail stations can be expected to attract the majority of commuters to the rail mode.

6. Mode of Access To and From Rail Stations

For station-area workers who commuted by rail, over half drove from their home to the station (Table 5.22). Around one out of five reached the station by foot. Once they reached their destination station, the overwhelming majority of rail commuters walked to their nearby workplace, especially in the case of BART (Table 5.23). The high incidence of park-and-ride access accounts for the greater amount of time usually spent getting from home to the origin station than from the exit station to the workplace (which was nearby and usually reached on foot) (Table 5.24). Clearly,

Table 5.22

Distribution of Mode of Access from Home to Rail Station, Commute Trip

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Walk	19.3%	22.4%	8.3%	22.2%	12.1%	40.0%
Drove Car	53.3	53.9	58.3	44.4	57.6	20.0
Rode as Passenger	11.1	7.9	8.3	22.2	18.2	0.0
Bus/other	16.3	15.8	25.1	11.2	12.1	40.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5.23

Distribution of Mode of Access from Rail Station to Workplace, Commute Trips

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Walk	85.9%	90.3%	83.6%	68.5%	87.1%	75.0%
Drove	6.9	5.6	7.3	6.5	6.5	0.0
Rode as Passenger	2.4	1.4	0.0	12.5	3.2	0.0
Bus/other	4.8	2.7	9.1	12.5	3.2	25.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5.24

Travel Times For Station Access, Commute Trips

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Travel time from Home to Rail Station						
Average (minutes)	16.49	17.27	19.00	8.33	16.20	n/a
(Std. Dev.)	(15.47)	(11.20)	(35.00)	(2.89)	(14.9)	
Travel time from Rail Station to Work						
Average (minutes)	5.66	11.58	2.25	8.43	4.88	n/a
(Std. Dev.)	(6.25)	(13..37)	(1.17)	(2.77)	(6.91)	

n/a = not available

in the absence of substantial amounts of transit-based housing, park-and-ride facilities are essential if station-area workers are to commute by rail in large numbers.

7. Travel Changes Over Time

Station-area workers were asked to provide information on their prior commute if they changed their place of employment, within the last three years, from some other place within the same metropolitan area that was not within walking distance of a station. Of the workers who now commute by rail (and who have not changed their residences), only 30.9 percent of those who use rail now used it before (Table 5.25).[6] From this, one can infer that working near a rail station raises the likelihood of commuting by rail by 30 or so percentage points, all else being equal.

Table 5.25

Comparison of Current Mode and Usual Mode at Prior Workplace for Those Living at Same Residence

Mode at Prior Workplace	Current Mode: Drove alone	Drove w/ others	Rode Car	Rail	Bus	Walk	Other
Drove	86.0%	71.4%	29.4%	61.9%	47.6%	16.7%	25.0%
Rode Car	1.8	12.8	47.1	0.0	0.0	16.7	0.0
Rail and walk	1.3	2.6	0.0	7.1	0.0	0.0	0.0
Rail and drive	6.6	7.7	0.0	19.0	0.0	16.7	25.0
Rail and Bus	0.4	2.6	0.0	4.8	4.8	0.0	0.0
All Rail	8.3	12.9	0.0	30.9	4.8	16.7	25.0
Bus	0.4	0.0	0.0	4.8	38.1	0.0	0.0
Walk	0.9	2.6	11.8	0.0	0.0	33.3	0.0
Other	2.6	0.0	11.8	2.4	9.6	16.7	50.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

8. Midday Trips

In the survey, workers were asked to record trips that they made during business hours outside the building that they work in. Since those making large numbers of midday trips likely depend on their cars for some of these trips (especially in the suburbs), it is unlikely they would commute by rail. Only 27.7 percent of those who traveled by rail to work left their building at all for any reason during the course of the work day, compared to 37.7 percent of those who got to work by other modes. Only 4.8 percent of those who commuted by rail left the building more than once during the day, compared to 9 percent of others. And only 12.8 percent of rail commuters left their workplace for personal or company-related business, whereas 28.6 percent of other commuters did.

Working near a rail station was not a strong inducement to use rail for midday travel. Only 2.7 percent of midday trips were by rail; three-quarters were made by car (Table 5.26). Six out of

Table 5.26

Mode of Midday Travel, by System

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Drove	74.8%	71.9%	82.5%	75.7%	77.2%	54.5%
Rode in Car	5.4	5.4	6.3	3.5	6.5	3.0
Rail and walk	2.3	2.1	10.0	0.7	0.8	3.0
Rail and drive	0.4	1.2	0.0	0.0	0.0	0.0
Rail and Bus	0.0	0.0	0.0	0.0	0.0	0.0
Bus	0.4	0.8	0.0	0.0	0.4	0.0
Walk	15.8	17.8	0.0	19.4	13.8	39.4
Other	0.9	0.8	1.3	0.7	1.2	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

seven midday trips made by rail were accessed by foot; the remainder were accessed by car. More trips (35.9 percent) were made for a meal or a snack than for any other reason, though trips made for personal business or employer-related business combined for over half of all midday trips (Table 5.27). Driving was the most popular means of travel for all midday trip purposes (Table 5.28). Walking accounted for 40 percent of all social and recreational trips and 39.3 percent of all trips made for medical purposes.

Table 5.27

Midday Trip Purpose, by System

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Business-Related	31.5%	23.4%	43.8%	38.4%	32.1%	28.6%
Personal Business	19.8	21.4	11.3	20.5	19.3	28.6
Meal or Snack	35.9	41.9	25.0	30.1	36.5	37.1
Shopping	4.1	4.8	6.3	4.1	3.2	0.0
Medical	4.7	4.8	6.3	2.7	5.6	2.9
Social/Recreational	2.6	1.6	3.8	3.4	2.8	2.9
Other	1.3	2.0	3.8	0.7	0.4	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5.28

Midday Modal Splits for Different Trip Purposes for Station-Area Workers

	Purpose						
Mode	Business-Related	Personal Business	Meal or Snack	Shopping	Medical	Social/Recreational	Other
Drove	87.5%	80.7%	62.1%	58.1%	53.6%	55.5%	66.7%
Rode in Car	3.9	3.4	8.9	3.2	3.6	0.0	0.0
Rail and walk	1.7	2.8	2.6	3.2	3.6	0.0	11.1
Rail and drive	0.0	0.0	0.0	0.0	0.0	0.0	11.1
Rail and Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bus	0.0	0.0	0.4	3.2	0.0	0.0	0.0
Walk	4.7	13.1	26.0	32.3	39.3	40.0	0.0
Other	2.2	0.0	0.0	0.0	0.0	5.0	11.1
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The average midday trip was 7.5 miles long and took 22.6 minutes, one-way (Table 5.29). Midday trips by station-area workers in the Sacramento area were the longest, perhaps because of the area's spread-out development pattern. Also, midday trips made by private automobile for business purposes were the longest and took the most time (Tables 5.30 and 5.31).

Table 5.29

One-Way Midday Trip Distance, Time, and Speed, by System

	All Systems	BART	SCCTA	CalTrain	RT	SDT
Trip Length (miles)						
Average	7.53	6.46	9.18	7.44	11.97	5.13
(Std. Dev.)	(16.50)	(11.19)	(11.11)	(8.59)	(24.58)	(4.60)
Trip Time (minutes)						
Average	22.59	17.93	20.72	25.74	24.45	12.46
(Std. Dev.)	(30.66)	(18.73)	(16.44)	(44.02)	(34.01)	(6.39)
Trip Speed (mph)						
Average	21.48	19.59	25.7	18.73	23.08	23.85
(Std. Dev.)	(17.14)	(18.09)	(16.31)	(14.02)	(16.61)	(25.57)

Table 5.30

Midday Trip Characteristics by Mode

	Drove Car	Rode Car	Rail	Walk
Trip Length				
Average (miles)	10.54	6.99	4.25	0.53
(Std. Dev.)	(18.12)	(14.93)	(4.16)	(1.08)
Trip Time				
Average (minutes)	23.75	15.00	18.00	12.01
(Std. Dev.)	(27.34)	(21.91)	(10.65)	(12.79)
Trip Speed				
Average (mph)	24.77	24.83	16.31	3.69
(Std. Dev.)	(16.06)	(12.59)	(12.54)	(11.81)

Table 5.31

Midday Trip Distance, Time, and Speed for Different Purposes

	Purpose					
Mode	Business-Related	Personal Business	Meal or Snack	Shopping	Medical	Social/Recreational
Trip Length						
Average (miles)	17.68	5.72	3.09	5.30	10.38	7.75
(Std. Dev.)	(26.25)	(6.00)	(3.53)	(7.24)	(13.33)	(12.49)
Trip Time						
Average (minutes)	37.28	17.28	11.90	17.42	23.79	25.88
(Std. Dev.)	(46.90)	(12.64)	(11.40)	(17.90)	(19.63)	(25.81)
Trip Speed						
Average (mph)	27.49	20.73	17.24	16.82	22.46	14.41
(Std. Dev.)	(17.80)	(15.61)	(16.21)	(18.22)	(16.32)	(13.87)

9. Conclusion.

Although, on average, the employment sites examined in this study produced lower rail modal splits than the residential projects examined in Chapter Four, they nonetheless exceeded the city- and county-wide averages everywhere except in San Diego. Station-area workers are far more likely to commute by rail if they also live near a rail station, receive a transit allowance, face the prospects of paid parking, and make few midday trips. These findings suggest public policy could play a significant role in allowing for the kinds of conditions that will attract significant numbers of Californians to rail transit.

Notes

[1]These figures reflect the unique character of the work sites included in this study. The disparity between this sample and the general population is partly accounted for by the criteria used to select sites for participation in the study, as discussed in chapter three. These criteria should also account for differences identified in occupational and employment characteristics of the sample when compared to the regions in their entirety.

[2]Respondents were asked to describe their morning commute to work by logging their mode of travel and various characteristics of their trip to work for the day on which they completed the survey.

[3]Although BART does serve Daly City, which is in the northernmost corner of San Mateo County, it presently serves no other part of that county.

[4]In general, station-area workers had higher rates of rail commuting than county-wide averages for all systems studied. The 8 percent SCCTA work-trip modal split compares to 3 percent for Santa Clara County as a whole in 1990. Even the 3.9 percent share of trips on CalTrain is more than twice the San Mateo County average of 1.7 percent for rail trips. The Sacramento Regional Transit split of 6.3 percent exceeds the 2.4 percent for the City of Sacramento. Only on the San Diego Trolley was there no substantial difference between the 3.2 percent rail modal split among respondents and the 3.3 percent citywide average.

[5]For other ratio-scale variables like commute distance, mean values are used in these simulations. In the second simulation, it is infeasible for trips to have both a San Jose origin and an origin in a city served by BART as well, so the San Jose dummy variable was set to zero, meaning the origin was a BART-served city.

[6]29.6 percent of those who took rail before they worked near rail continue to do so, indicating that there is some attraction of rail ridership which supercedes proximity of employment to rail.

Chapter Six

Modal Access to Retail Centers Near BART Stations

1. Introduction

Transit is not usually viewed as a viable mode for shopping trips. This is mainly because the private automobile is often far more convenient for carrying merchandise and purchased goods. Automobiles also can reach all possible shopping destinations; not all suburban shopping centers, on the other hand, are served by transit.

This chapter examines the travel characteristics of shoppers and others (e.g., employees) at three large Bay Area shopping complexes located within a quarter-mile of a BART station. One of the centers studied is the San Francisco Centre, which is directly connected to the Powell Street station in downtown San Francisco. The other two surveyed centers are in the East Bay— El Cerrito Plaza (near El Cerrito station) and Bayfair Shopping Mall (near the San Leandro station). Both are among the largest shopping complexes outside of a Bay Area CBD, and are the largest non-downtown centers within a quarter-mile of a BART station. All three shopping centers are fully or partially enclosed master-planned complexes and are served by bus transit in addition to BART.

The Sites

San Francisco Shopping Centre (SFCentre) lies on the south side of Market Street in downtown San Francisco, adjacent to BART's busiest station— Powell Street. It is the largest of the surveyed shopping centers, containing nearly one million square feet of retail space. The four-story structure has two large anchor tenants and a number of specialty stores that cater to relatively affluent customers and tourists. Only commercial-rate parking is available in the immediate area —which can run upwards of $3 per hour.

El Cerrito Plaza is a large community scale shopping center with 439,000 square feet of retail space and 2,850 free parking spaces. El Cerrito has only one large department store anchor and fronts a major arterial lined with strip commercial development. To the north and west of the center is a relatively dense residential development (at 35 dwelling units to the acre). To the east and south is single-family detached housing at 8 dwelling units to the acre.

Bayfair is a small-scale regional shopping center, with 760,000 square feet of retail space and 3,800 parking spaces. Recently renovated, Bayfair is asurrounded mainly by small retail plazas and strip commercial developments inaterspersed with apartment complexes.

Survey Approach

For each site, pedestrian intercept surveys were conducted. Interviews were fairly brief (typically under one minute) and were conducted at all major entrances to each center in order to minimize possible biases. Surveys were carried out in early 1993 over several days, between two and five p.m. To the extent possible, each person above 18 years of age who passed an interviewer was approached about being surveyed. People were told the survey was brief, anonymous, and voluntary. Around one in every two persons approached in SFCentre agreed to participate, compared to around one in every four at Bayfair and El Cerrito. Approximately, three hundred surveys were collected at each center. In addition to information on how individuals reached the shopping center, background socio-economic data were also compiled. A copy of the pedestrian intercept survey form is shown in Appendix C.

2. Demographic Background

The typical person surveyed was a female in her early 30s (Table 6.1). The relatively large share of women reflects the tendency for women to do family shopping and their high rate of employment in retail sales.

The ethnic composition of those surveyed at the malls varied considerably. Around half were white. At Bayfair, a large share of those surveyed were African Americans. Additionally, a relatively large share of those present at SFCentre were foreign tourists, many of whom were European.

Table 6.1

Demographic Characteristics of Those Surveyed at Three Bay Area Shopping Centers

	All Centers	SF Centre	Bayfair	El Cerrito
Age				
Average	34.2	32.7	31.3	38.6
(Std. Deviation)	(13.6)	(11.6)	(12.7)	(15.3)
Percent Female	53.3	51.5	51.5	57.8
Ethnicity —Percent				
African American	24.4	12.4	41.6	21.3
Asian American	14.6	16.9	10.3	16.2
Hispanic	9.2	8.8	14.4	4.8
White	50.3	60.3	32.6	56.6
Other	1.5	1.6	1.1	1.1
TOTAL	100.0	100.0	100.0	100.0

3. Comparison of Retail Centers' Trip Characteristics

Modal Split

Around 15 percent of those surveyed arrived at the shopping center by BART, a distant second after the automobile and only a slightly higher share than walking (Table 6.2). More people reached the SFCentre exclusively by foot than by any other means of access. SFCentre has a large potential market of shoppers who work or reside in and around downtown. It is surrounded by skyscrapers filled with office workers, hotels full of tourists, and a densely populated city. The setting is more conducive to walking than driving. The BART and Muni train stations are directly connected to SFCentre by a subway portal. Nearby parking can be quite expensive and hard to find. Often those driving must walk farther than if they had used BART or Muni to reach the SFCentre.

Table 6.2

Mode of Access to Retail Centers

	All Centers	SFCentre	Bayfair	El Cerrito
Percent of Trip by:				
Drive Car	44.7	17.5	56.9	64.0
Ride Car	10.7	6.9	15.1	10.7
Rail Transit[1]	15.4	20.8	18.8	6.6
Bus	7.3	13.0	4.4	4.0
Walk	16.4	31.8	3.5	12.2
Other	5.5	10.0	1.3	2.5
TOTAL	100.0	100.0	100.0	100.0

[1]Includes BART heavy rail and Muni light rail and cable-car services.

n=845

The opposite is true for the suburban malls, where the private automobile is the most convenient means of access. Well over fifty percent of those interviewed at both Bayfair and El Cerrito drove to the malls. Nearly one out of five of Bayfair interviewees reached the mall by BART, compared to only 6 percent of those at El Cerrito.

The abundant free parking —both surrounding the malls and at the nearby BART stations —surely accounts, in part, for the higher rates of auto access to El Cerrito and Bayfair. Automobile availability also explains some of the differences— only 47 percent of those at SFCentre had a vehicle available, compared to more than 75 percent at El Cerrito and Bayfair.

Trip Purpose

Today's retail centers incorporate many features of a small town center— banks, eateries, offices, health clubs, movie theaters, and salons, among other activities. As might be expected, most of those surveyed went to the retail centers primarily to shop (Table 6.3). Still, around one-quarter of those were at the shopping center for some other reason. At the SFCentre, 12 percent went mainly to eat. At El Cerrito, around 14 percent were at the mall to make a banking transaction or to meet a friend.

Table 6.3

Primary Purpose of Trip to Retail Center

	All Centers	SF Centre	El Cerrito	Bayfair
Percent of Trips for:				
Shopping	73.7	75.2	73.6	72.2
Eating	7.9	12.1	3.3	7.9
Business	2.1	2.0	1.8	2.6
Employee	6.2	3.3	7.7	7.9
Other[1]	10.1	7.4	13.6	9.4
TOTAL	100.0	100.0	100.0	100.0

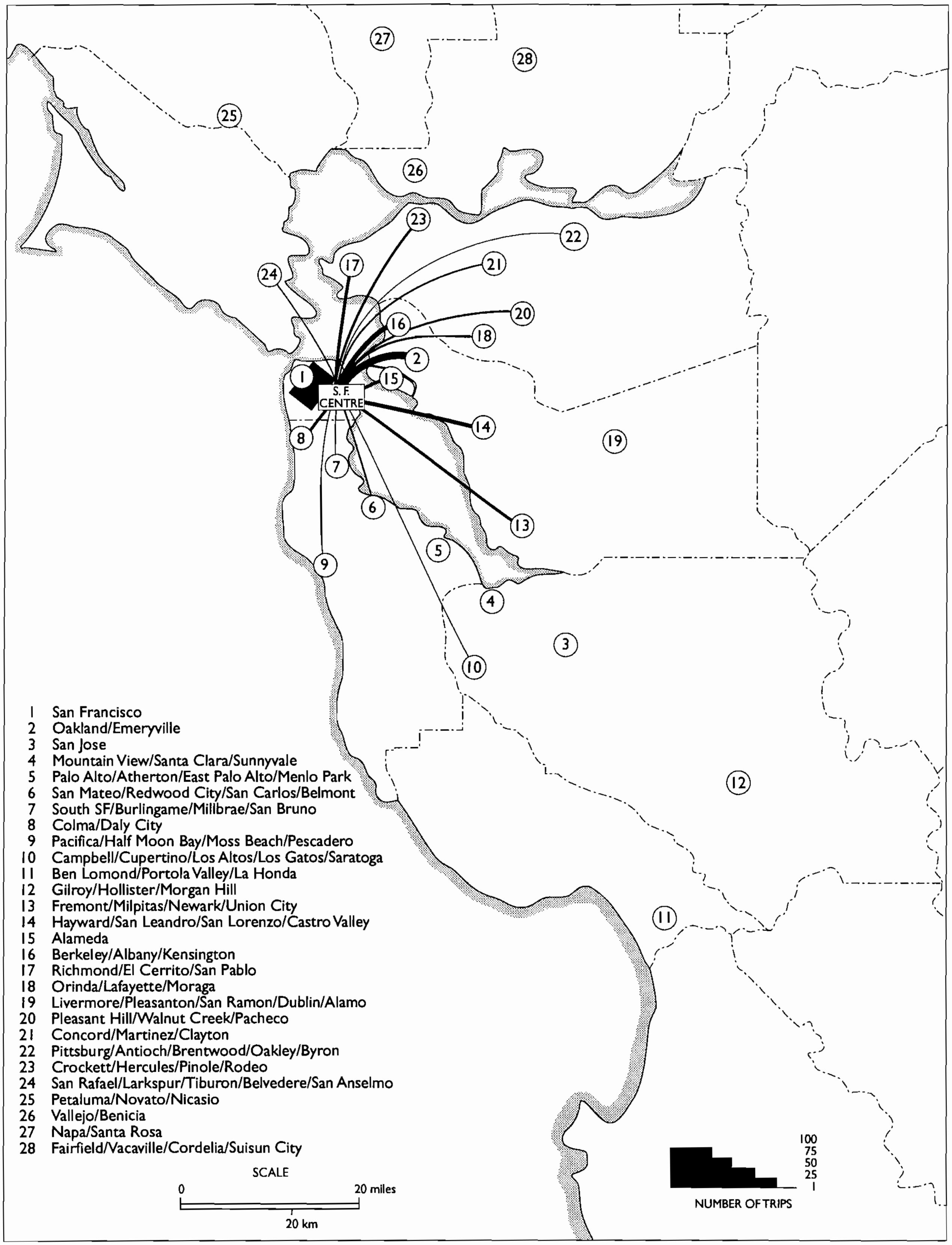
[1]'Other' includes banking, meeting people, hanging out with friends, and other activities.

Market Draw

Based on information gathered on interviewees' places of residence, Map 6.1 shows that SFCentre attracted people who resided throughout the Bay Area. By contrast, El Cerrito and Bayfair served more local clientele within the East Bay (Maps 6.2 and 6.3). Since rail transit is generally more attractive for shop trips made over long distances (typically to purchase more costly, high-quality apparel and other light merchandise), it follows that SFCentre's relatively high share of BART users reflects its larger retail marketshed.

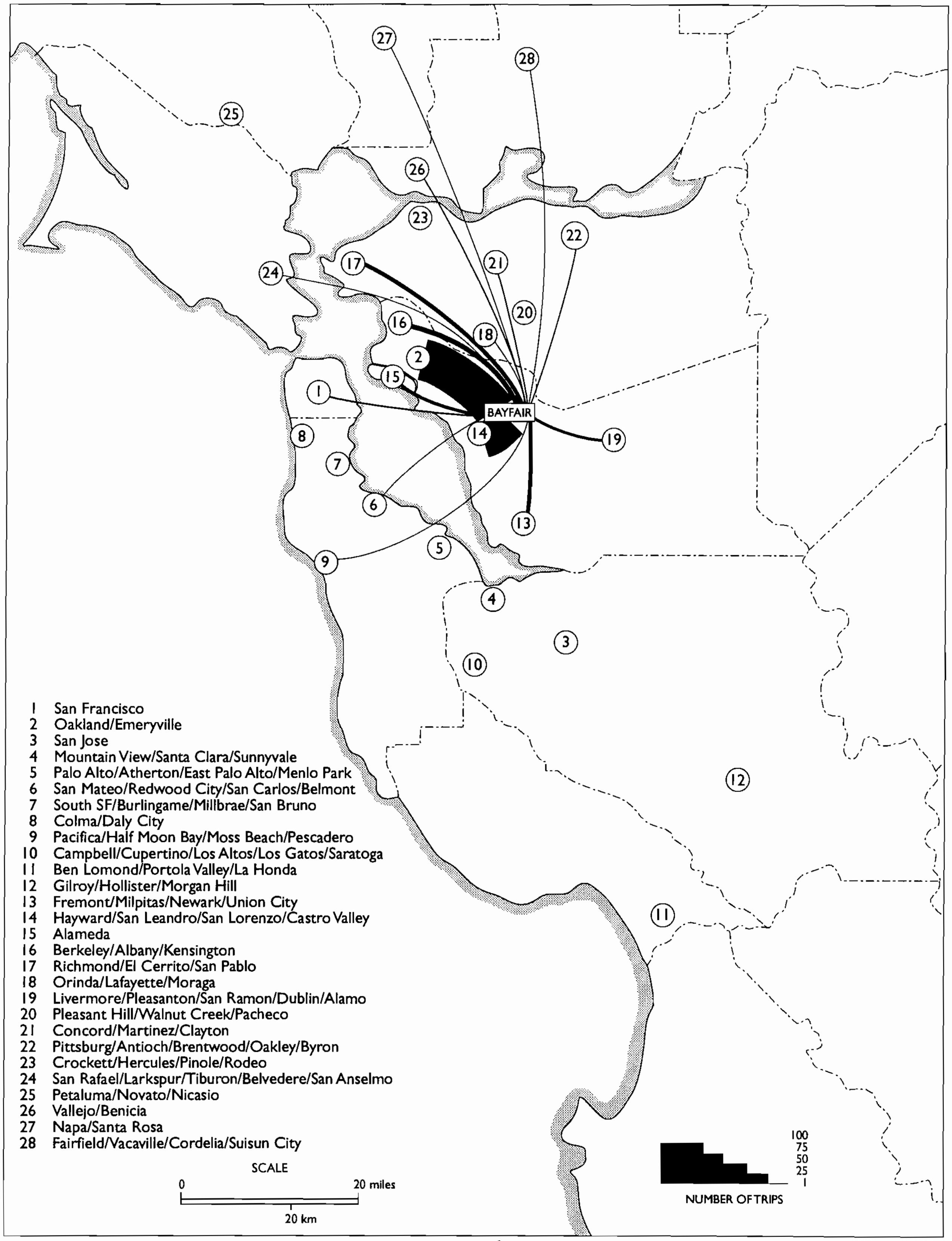
Place of Origin and Distance Traveled

Another indicator of market draw is the distance between the shopping center and the last place visited, which can also include an individual's home. Conventional wisdom holds that the largest shopping center has the largest regional draw. Table 6.4 shows that this theory holds for the two East Bay malls. At El Cerrito, the smallest center, the majority of visitors arrived from an origin within five miles, while at Bayfair a relatively large share came from up to 20 miles away. For both malls, over half of those surveyed traveled directly from their residence to the mall (Table 6.5). Bayfair had a much higher share of shoppers who dropped by en route from their offices (mainly in San Francisco and Oakland) to home. This higher capture of pass-by commuters heading home accounts for Bayfair's large share of long-distance arrivals.



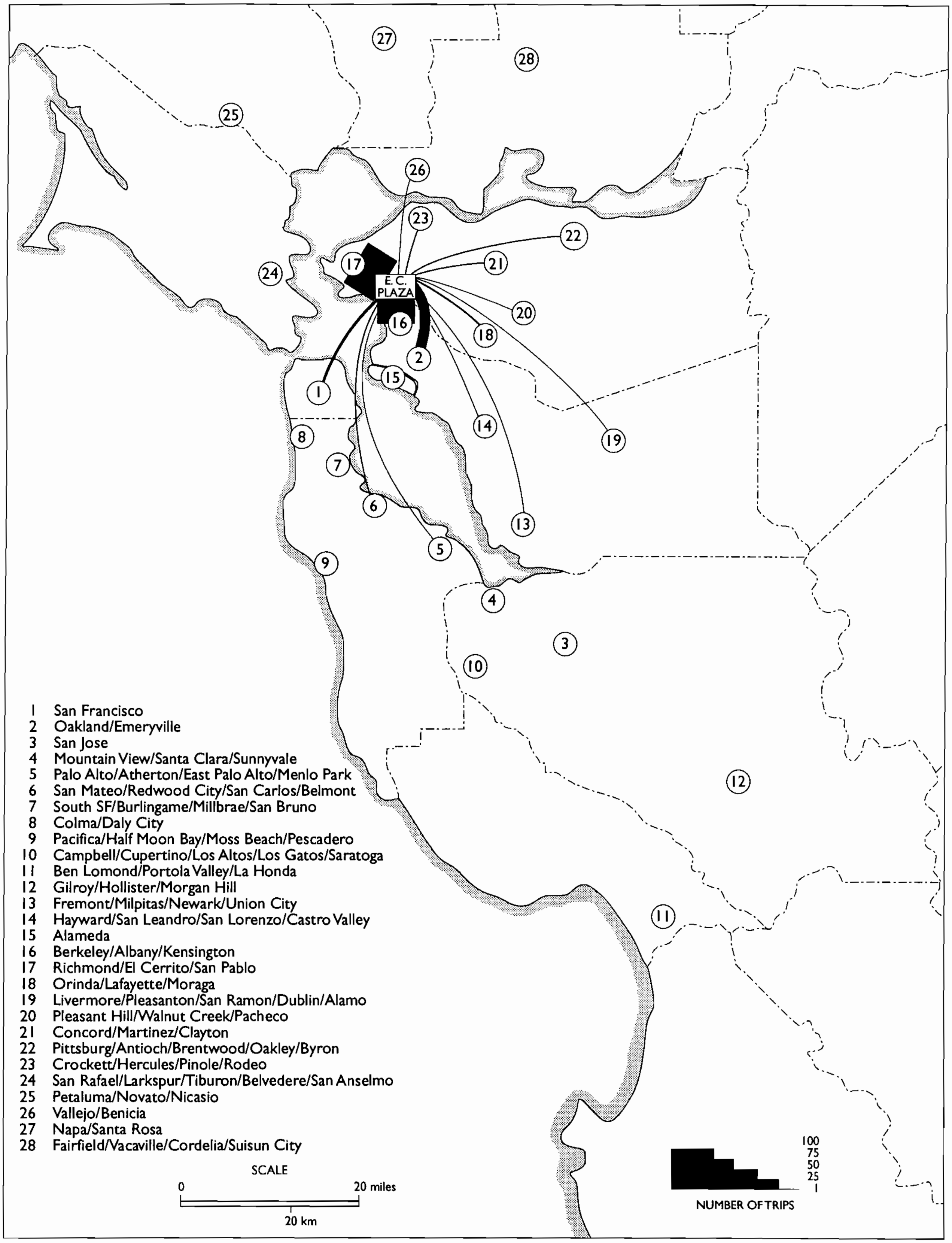
Map 6.1

SFCentre's Marketshed



Map 6.2

Bayfair's Marketshed



Map 6.3

El Cerrito's Marketshed

Table 6.4 shows those at SFCentre traveled a wide range of distances to get there. Since it attracts a large number of downtown workers and visitors (Table 6.5), SFCentre drew over a third of its customers from locations within a one-mile distance. However, SFCentre also had a relatively large share of surveyed individuals who came from beyond 20 miles away. Long-distance shoppers usually arrive directly from their homes, and are willing to endure long trips because of SFCentre's wide variety of shops and other downtown attractions.[1]

Table 6.4

Distance From Last Place Visited to Retail Center

	All Centers	SF Centre	Bayfair	El Cerrito
Percent Coming From:				
< 1 Mile	19.6	34.8	4.8	16.0
1-5 Miles	46.2	34.1	42.3	66.4
6-10 Miles	12.7	10.2	19.5	7.9
11-20 Miles	13.0	7.2	24.5	7.8
>20 Miles	8.5	13.7	8.9	1.9
TOTAL	100.0	100.0	100.0	100.0

Table 6.5

Place of Origin for Trips to Retail Center

	All Centers	SF Centre	El Cerrito	Bayfair
Percent Coming From:				
Office	18.0	19.2	11.8	22.8
Home	47.9	36.8	52.4	56.7
Friend	6.5	9.4	6.9	3.0
Other Store	5.6	2.9	8.8	5.3
Hotel	7.0	19.2	0.0	0.0
Other[1]	15.0	12.5	20.1	12.2
TOTAL	100.0	100.0	100.0	100.0

[1]'Other' includes banking, school, restaurant, medical appointment, and picking up or dropping off people.

4. Influences of Various Factors on Rail Transit Usage

Sociodemographic Factors

Larger shares of women than men took transit or rode as car passengers to reach the shopping centers (Table 6.6). Also, those arriving by rail transit tended to be younger than those who drove alone to a center. Moreover, larger shares of Hispanics and African Americans arrived at centers by rail transit than any other ethnic group. Around one out of five Asian Americans and whites surveyed at centers arrived exclusively by foot travel. In general, the largest share of rail users surveyed at shopping centers came from groups which have historically been the most transit-dependent —women, younger people, and ethnic minorities.

Table 6.6

Modal Splits for Different Demographic Groups of Surveyed Shoppers

	Percent		Average	Percent From Ethnic Group				
	Female	Male	Age (yrs.)	African American	Asian American	Hispanic	White	Other
Rail Transit	17.3	11.1	30.3	19.9	17.0	24.3	15.8	9.1
Bus	7.8	8.4	32.6	11.7	7.3	7.2	5.4	0.0
Drove Car	42.1	53.6	36.2	45.8	39.2	47.4	45.6	36.3
Rode Car	14.9	12.6	30.3	11.8	13.0	10.9	9.4	9.1
Walk	15.3	11.7	33.8	8.5	19.5	10.2	20.1	45.5
Other	2.6	2.6	38.3	2.3	4.0	0.0	7.3	0.0
TOTAL	100.0	100.0	34.2	100.0	100.0	100.0	100.0	100.0

Purpose of Visit and Modal Split

Table 6.7 shows that shoppers patronized rail transit less than those who went to the shopping center to work, for personal business, or virtually any other purpose. By comparison, over a third of those who came to eat, work, or for some other reason came by some form of mass transit (either rail or bus). This pattern probably reflects the fact that rail is less convenient for shopping (e.g., carrying packages) than for other purposes.

Table 6.7

Modal Splits for Different Purposes for Coming to the Shopping Center

	Trip Purpose				
	Shopping	Eating	Personal Business	Work	Other
Rail Transit	15.3%	25.5%	33.3%	21.3%	25.0%
Bus	6.3	11.5	5.6	11.5	9.2
Drove Car	46.7	31.4	50.0	50.0	35.5
Rode Car	12.4	4.2	11.1	3.8	7.3
Walk	16.5	21.4	0.0	9.6	18.4
Other	2.8	6.0	0.0	3.8	4.6
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Relationships did vary considerably among shopping centers, however. Around one-quarter of SFCentre's shoppers arrived by rail transit, compared to only 4.5 percent of El Cerrito's shoppers (Table 6.8). One-third of SFCentre's shoppers walked directly from their origin to the shopping complex, compared to only 3.6 percent of Bayfair's shoppers. Over three-quarters of both Bayfair's and El Cerrito's shoppers either drove or rode as a passenger to reach the malls.

Table 6.8

Purpose Of Trip By Mode Per Mall

	Shopping	Eating	Business	Employee	Other
SFCentre					
Rail Transit	24.2%	32.4	50.0%	40.0%	39.0%
Bus	11.7	18.9	0.0	40.0	8.7
Drove Car	18.2	10.8	50.0	10.0	13.1
Rode Car	9.1	0.0	0.0	0.0	0.0
Walk	33.3	35.1	0.0	10.0	26.1
Other	3.5	2.8	0.0	0.0	13.1
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Bayfair					
Rail Transit	15.7%	19.0%	14.3%	28.6%	32.0%
Bus	1.6	4.8	14.3	4.8	20.0
Drove Car	60.9	61.9	57.1	42.8	32.0
Rode Car	16.1	14.3	14.3	9.5	12.0
Walk	3.6	0.0	0.0	4.8	4.0
Other	2.1	0.0	0.0	9.5	0.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
El Cerrito					
Rail Transit	4.5%	22.2%	40.0%	4.8%	10.8%
Bus	4.5	0.0	0.0	4.8	2.7
Drove Car	66.0	55.6	40.0	76.2	51.4
Rode Car	12.5	0.0	20.0	0.0	8.1
Walk	10.0	22.2	0.0	14.2	21.6
Other	2.5	0.0	0.0	0.0	5.4
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Walking access was popular among those who went to SFCentre to eat. The next most common means of accessing SFCentre for lunch and dinner was by transit. Over 40 percent of SFCentre's diners arrived by rail or bus.

Influence of Distance Traveled

Trip distance was a strong predictor of mode choice among those surveyed at the three shopping centers (Table 6.9) In general, rail transit usage increased as trip distance increased — 36 percent of those traveling over 20 miles arrived at a shopping center via rail transit, compared to only 12 percent of those traveling one to five miles. In contrast, bus usage fell with distance.

Evidently, because of its line-haul, limited-stop service features, rail transit is preferred by those traveling more than five miles to a shopping center near a BART station.

Table 6.9

Modal Splits for Different Trip Distance Categories

	Trip Distance (Miles)				
	<1 Mile	1-5 Miles	6-10 Miles	11-20 Miles	>20 Miles
Rail Transit	8.3%	11.8%	27.3%	22.5%	35.9%
Bus	9.6	8.6	4.0	4.9	0.0
Drove Car	17.1	53.7	51.5	57.8	43.3
Rode Car	1.3	12.8	14.1	13.7	17.9
Walked	60.5	9.7	1.0	0.0	0.0
Other	3.2	3.4	2.1	1.1	2.9
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Walkers, of course, trekked relatively short distances to BART-served shopping centers. Beyond one mile, there was little relationship between distance and automobile travel— shoppers traveling five or 15 miles to one of the retail centers were just as likely to arrive by car. Overall, automobiles were relied on most heavily to reach rail-served shopping centers regardless if the trip was short or long. Drive-alone shoppers represented the largest market share in the short (1-5 miles) and intermediate (11-20 miles) distance categories.

Place of Origin

More than twice as many people whose trip originated at home or work drove to one of the shopping centers as those who took rail transit (Table 6.10). In general, from the hotel people walked, from the store they drove, and from a friend's house their modal choice was evenly mixed.

Table 6.10

Modal Splits for Different Trip Origins

	Place of Trip Origin					
	Office	Home	Friends	Store	Hotel	Other
Rail Transit	23.1%	19.0%	18.2%	12.8%	8.5%	14.2%
Bus	6.6	6.7	12.7	6.4	8.5	7.9
Drove Car	48.0	48.4	34.5	59.6	8.5	44.9
Rode Car	5.9	12.1	18.2	10.6	3.4	11.8
Walk	13.8	11.4	16.4	4.3	66.1	17.3
Other[1]	2.6	2.4	0.0	6.3	5.0	3.9
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

[1]'Other' includes banking, school, restaurant, medical appointment, and picking up or dropping off people.

5. Summary

This chapter profiled people interviewed at three large shopping centers near BART stations. In total, around 15 percent of those surveyed at the three shopping centers adjacent to BART stations patronized rail transit. Most were choice riders. The choice to ride rail seemed most heavily influenced by parking availability —around 21 percent of those surveyed at SFCentre, which has no free parking, arrived by rail transit, compared to only 6.6 percent at El Cerrito, a suburban-like plaza with plentiful free parking. Around three-quarters of those at Bayfair and El Cerrito arrived by automobile, compared to less than one-quarter at SFCentre. Clearly, parking supply and price has a lot to do with whether those shopping or doing business at shopping centers near regional rail stations will ride rail transit.

The immediate built environment also seems to have a strong bearing on rail ridership among shoppers. In addition to parking restraints, SFCentre lies in a dense, mixed-use downtown setting and draws a mixed clientele of workers shopping on their lunch breaks, tourists staying in nearby hotels, and Bay Area residents who travel long distances to shop there. Besides BART and Muni, many SFCentre patrons arrive exclusively by foot. Bayfair and El Cerrito, on the other hand, are in suburban-like environs where horizontally scaled buildings create long walking distances, even to neighboring plazas. In the case of Bayfair, only 3 percent of the surveyed shoppers reached the mall by walking; evidently, many were unwilling to brave crossing the busy commercial thoroughfares and expansive parking lots to reach Bayfair from nearby residential neighborhoods and retail plazas.

In closing, the findings in this chapter suggest that placing retail centers near rail stations will only attract significant numbers of shoppers to rail if some restrictions are placed on parking and densities are high enough to encourage walking over automobile circulation. Having a large population of residents and employees nearby also encourages non-auto forms of access to retail centers near rail stations. It follows, then, that rail stops with retail activities need to be mixed with residences and workplaces if significant numbers of shoppers are expected to patronize transit or arrive by foot. Thus, consistent with the findings of the two previous chapters, retail activities require complementary land uses if transit-focused shopping complexes are to yield significant mobility benefits. This further suggests that transit-focused development needs to be in the form of transit villages — moderately dense mixed-use communities with limits on parking —if substantial shares of travelers are to be lured out of their automobiles.

NOTES

[1]El Cerrito and Bayfair do not show marked difference between market share and distance from the last place visited. For these retail centers, those interviewed came primarily from nearby communities. SFCentre, by contrast, is located in a busy tourist area and is surrounded by many other downtown attractions.

Chapter Seven

Site Characteristics of Station-Area Developments and their Impact on Rail Ridership

1. Introduction

This chapter explores the relationships between transit ridership and various characteristics of the 27 residential and 18 office sites surveyed. Whereas the previous three chapters examined factors influencing the individual mode choices of residents, workers, and shoppers, by aggregating data for each site, this chapter focuses on how the physical environment and relative proximity of each site to rail stations affect demand. Thus, the two central areas of exploration in this chapter are:

(1) how the land-use and physical characteristics of sites (and areas surrounding them) influence rail usage; and
(2) the degree to which rail ridership decreases as walking distance to a station increases.

Answers to these questions can guide planners in assessing:

(1) the types of development most appropriately placed near rail transit stations;
(2) the density and physical development characteristics that are most conducive to rail usage; and
(3) the relative importance of proximity and clustering in inducing those living and working near rail stations to use rail transit.

2. Building a Database

In order to investigate these questions, it was necessary to build a database containing information on the physical and design characteristics of each of the surveyed sites. Additionally, since the quality of the environment for pedestrians from sites to nearby stations was also a possible factor influencing whether significant shares of residents or workers patronized rail, data were compiled on the distance between sites and stations and other indicators of environmental quality.

Residential Sites

Data collected for residential sites included:

- Number of units by size and price
- Land area
- Dwelling units per acre[1]
- Floor area ratio[2]
- Number of parking spaces
- Cost of parking per month
- Distance from the nearest station[3]
- Distance from the nearest freeway on-ramp[4]

Because the physical and environmental characteristics of the entire community around a station were considered as important as those of individual sites, the following area-wide data were also compiled:

- Residential densities of the census tract of the site[5]
- Levels of land-use mixture in the census tract of the site[6]
- The number of signalized crosswalks between the site and the nearest station[7]
- The width of the widest street crossing between the site and the nearest station[8]
- Whether or not there were continuous sidewalks or exclusive pedestrian paths between the site and the nearest station

Office Sites

For office sites, similar data were gathered:

- The number of tenants in the building
- Number of employees at the site
- Gross building area, in square feet
- Land area in acres
- Employees per acre[9]
- Floor area ratio
- The monthly rent or lease, per square foot
- Cost of parking per month for employees
- Number of parking spaces

Also, the following areawide measures and indicators of walking environment were measured:

- Distance from the nearest station
- Distance from the nearest freeway on-ramp
- Mix of land-uses in the census tract of the site
- Employment densities of the census tract of the site
- The number of signalized crosswalks between the site and the station
- The width of the widest crosswalk between the site and the station
- Whether or not there were continuous sidewalks or exclusive pedestrian paths between the site and the station

Quality of the Walking Environment

Measuring the quality of the walking environment is not easy, in part because people perceive physical environments so differently. While some walkers prefer the straightest possible path, regardless of how barren or blighted the surroundings might be, others are attracted only to tree-lined winding pathways or corridors with commercial storefronts. Others have tried to gauge the quality of the walking environment with varying degrees of success, although no fully satisfactory indicators have been developed to date as far as we know. Certainly no single indicator fully captures the multitude of factors that shape peoples' perceptions of walking quality. For the purposes of this study, the following indicators were used, which in combination tap into the dimensions of spatial distance, impedance, and facility provision.

- Distance to station: distance from the station to the site was measured from the nearest ticket machine to the main entrance for office sites and to the geographic center of residential sites.
- Continuous sidewalks: whether or not sidewalks cover the entire distance from the site to the station, not including parking lots of either the station or the site.
- Pedestrian Paths: a site was considered to have a pedestrian path to the station if any paved right-of-way was provided specifically for pedestrians that was not part of a sidewalk, immediately adjacent to curbsides, or as part of a parking lot.
- Number of signalized crosswalks: this reflected the degree to which there were conflict points between pedestrians and vehicular traffic.
- Street widths at widest crosswalk: this reflected the relative scale of intersections (which represent pedestrian-car conflict points).

3. Ridership Gradients

We would expect that the closer a person is to a rail station, the higher the likelihood that this person uses rail, all else being equal. Earlier studies, discussed in Chapter Two, suggested that distance indeed influenced the propensity to use transit. In Washington, D.C., ridership fell rapidly with distance within a one-half-mile radius of stations. In the case of Toronto and Edmonton, the difference in the share of residents or workers in a building immediate to a station who use rail transit was greater over a one-mile radius than a one-half-mile radius. In both of these studies, the relationship between rail modal splits and distance was not linear, implying that effects of distance change as one approaches the station. A recent study of commuting in greater Toronto confirmed the importance of proximity to subway as the primary determinant of mode choice (Pivo, 1993).

Residential Sites

Table 7.1 shows the recorded walking distances from the center of each surveyed residential site to the ticket machine of the nearest rail station. Plotting these data against the percent of residents in each site who used rail to get to work (shown in Chapter Four) produces Figure 7.1. The plot is broken down into two groups: residential sites along the BART line, and other surveyed residential sites.

The negative slopes of both best-fitting lines indicate that distance indeed had a deterring effect on commuting by rail transit; however, the relationship was not particularly strong. This is further revealed by the relatively low R-squared goodness-of-fit statistics for both sets of stations:

BART: Percent Rail = -.004(Distance) + 31.16 $\quad R^2 = .119$ (7.1)

Other: Percent Rail = -.011(Distance) + 32.61 $\quad R^2 = .280$ (7.2)

For BART, the ridership gradient was linear, though the relationship between rail usage and distance was weak. A stronger relationship held for the other four California rail systems. On average, rail's modal share fell about 1.1 percentage point for every 100-foot increase in walking distance to non-BART projects.

Table 7.1

Recorded Walking Distances from Residential Sites to Nearest Station

Site	Nearest Station	Distance to Station (ft.)
BART		
Mission Wells	Fremont	1,150
Verandas Apts	Union City	1,100
Parkside Apts	Union City	600
The Foothills Apts	South Hayward	770
Mission Heights Apts	South Hayward	2,620
Summerhill Terrace Apts	Bayfair	3,100
Bayfair East	Bayfair	2,800
The Hamlet Apts	Bayfair	1,050
Nobel Tower Apts	Lake Merritt	1,330
Wayside Plaza	Pleasant Hill	1,760
Park Regency Apts	Pleasant Hill	1,570
CalTrain		
Hillsdale Garden Apts	Hillsdale	2,170
Grosvenor Park Condominiums	San Mateo	1,790
Northpark Apts	Broadway	1,150
Palo Alto Condominiums	Palo Alto	1,510
Santa Clara County Light Rail		
Bella Vista Apartments	Lick Mill	3,530
Stonegate Condominiums	Tamien	1,330
Willow Glen Creek Condos.	Tamien	1,760
Park Almaden Condominiums	Almaden	990
Sacramento Regional Transit		
Woodlake Close Apartments	Royal Oaks	1,730
Oaktree Apartments	Tiber	480
Woodlake Village Apartments	Power Inn	2,920
Windsor Ridge Apartments	Butterfield	1,320
San Diego Trolley		
Villages of La Mesa	Amaya Dr.	500
Park Grossmont	Amaya Dr.	2,640
La Mesa Village Plaza	La Mesa Blvd.	320
Spring Hill Apartments	Spring St.	850

For all California systems combined, the relationship between rail ridership and distance was also linear, but the fit was stronger.

$$\text{Percent Rail} = -.0085(\text{Distance}) + 32.24 \qquad R^2 = .381 \qquad (7.3)$$

Figure 7.2 shows that, relative to the other two areas studied to date, rail usage among residences within a mile radius of California rail stations was far lower than that found for Washington Metrorail stations and stations near Toronto's and Edmonton's rail systems. Also, the relationship between ridership and distance was weaker in California, reflected by the flatter line. Some of this difference might be explained by the fact that most of the California rail systems studied function

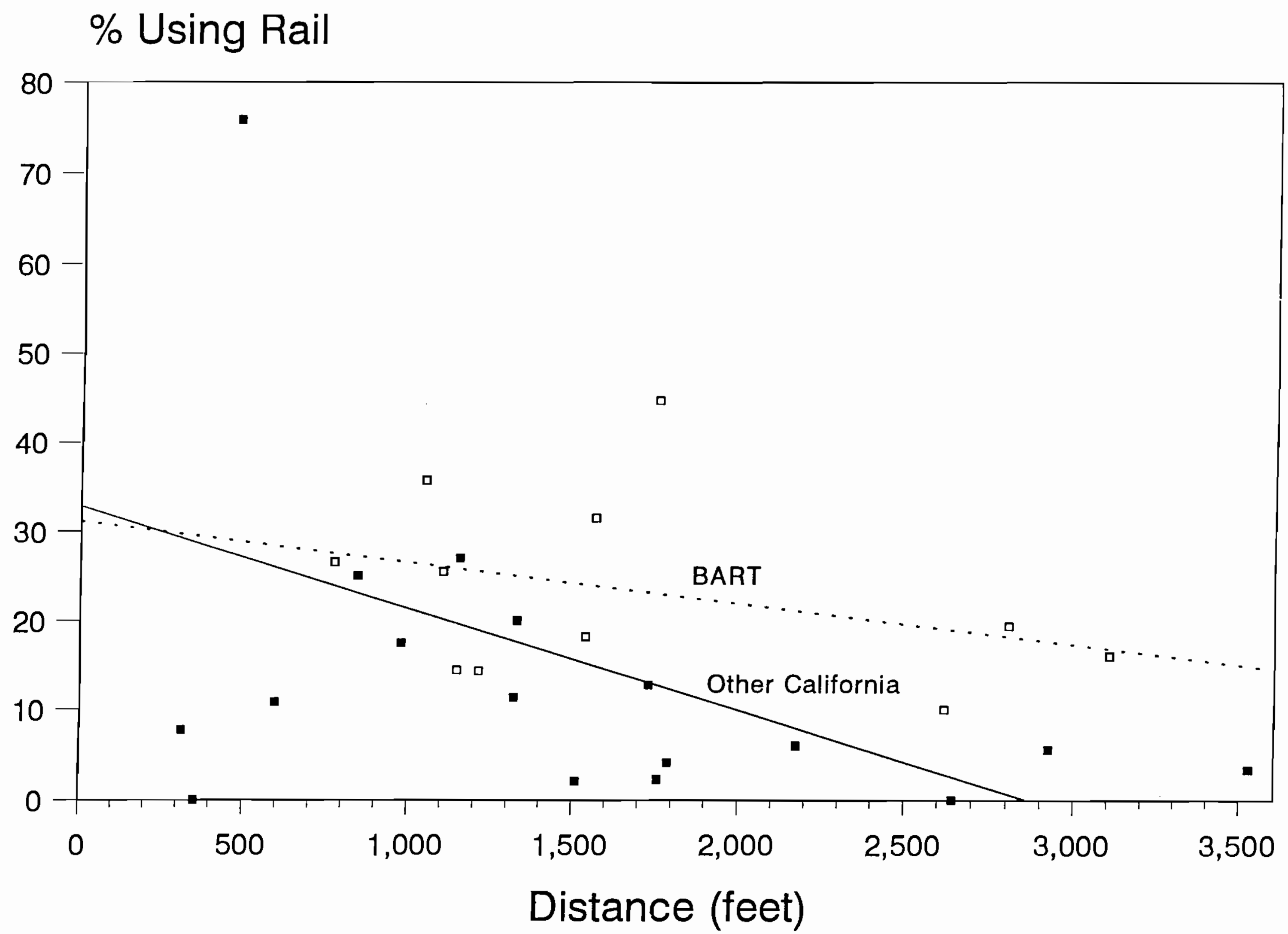
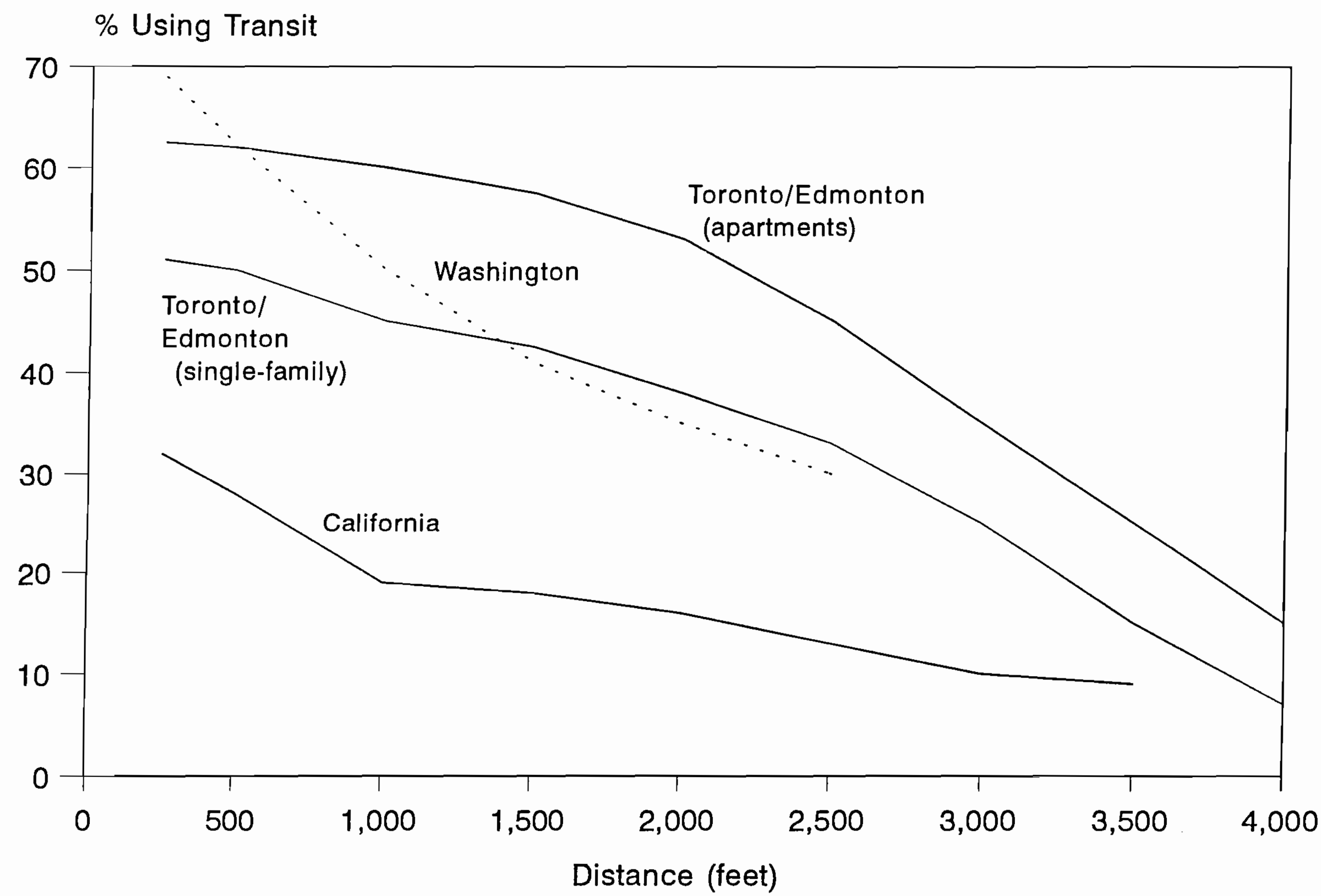


Figure 7.1

Rail Mode Share by Distance to Residential Sites, California Systems



Sources: Stringam (1983); JHK (1989)
Note: Washington data includes all transit

Figure 7.2

Rail Mode Share by Distance to Residential Sites, Comparison of California and Other Systems

mainly as commuter systems, and thus have suburban stations with abundant park-and-ride facilities. As noted in Chapter Four, around 10 percent (and in the case of Sacramento RT, 21 percent) of the surveyed station-area residents who used rail accessed the stations by car, even though all lived within 3,500 feet (and the majority within 1,500 feet) of a station. Thus, the availability of large amounts of parking at many California suburban rail stations has drawn a much larger share of these systems' rail users from beyond normal walking distances. Higher average residential densities, better feeder bus connections, and perhaps even better quality walking environments might also explain why these other cities have managed to capture higher shares of rail users among station-area residents than in California.

Office Sites

Recorded walking distances between surveyed offices and nearby stations are shown in Table 7.2. Walking distances varied more for surveyed offices than for surveyed residential sites.

Table 7.2

Recorded Walking Distances from Office Sites to Nearest Station

Site	Station	Distance to Station (ft)	No. of Workers
BART			
Citibank	Pleasant Hill	660	350
Pacific Bell	Montgomery St.	490	550
Fremont Center Building	Fremont	1,000	300
39350 Civic Center Dr.	Fremont	1,470	235
Great Western Building	Berkeley	50	275
CalTrain			
Digital Equipment	Palo Alto	450	400
Homart	South S. F.	3,410	1,800
Mountain View City Hall	Mountain View	2,810	150
Santa Clara County Light Rail			
Northpointe Bus. Ctr.	Tasman	490	75
San Jose Corporate Ctr.	Metro/Airport	420	300
Koll Center	Karina Court	420	1,000
Sacramento Regional Transit			
California Center	Watt/Manlove	1,130	1,000
Mayhew Tech Center	Tiber	1,870	605
Franchise Tax Board	Butterfield	1,560	3,000
Dept. of Conservation	8th and K St.	370	398
San Diego Trolley			
Latham & Watkins	Gaslamp	680	160
St. John Knits	Iris Ave	3,200	106
Southwest Marine	Bario Logan	2,080	1,200

The ridership gradient for office sites are shown in Figure 7.3. Compared to the residential sites, the effects of distance on rail commuting was fairly substantial.[10] For office sites, ridership fell sharply with walking distance, following the negative exponential function shown in equation 7.4 (i.e., rail share fell, though at a decreasing rate, with distance). In the case of BART sites, around one-half of workers at the two office buildings within 50 feet of a station commuted by BART; for the remaining three buildings that were 500 to 1,500 feet away, the modal splits were around 10 percent. For the non-BART sites, only offices within 500 feet had as much as 15 percent of their workers commuting by rail; beyond 500 feet, no more than 10 percent of workers took rail to work.

$$\text{Percent Rail} = 1{,}105(\text{Distance})^{-.795} \qquad R^2 = .381 \qquad (7.4)$$

Figure 7.4 shows that, compared to Washington Metrorail and Toronto/Edmonton, California rail systems captured smaller shares of station-area workers, though differences were not large. Differences could be attributable to a number of factors, including the larger service coverage of Metrorail and the Canadian systems vis-á-vis most California systems or differences in employee parking policies. Such possibilities merit future research attention. California systems, however, had ridership gradients equally as steep as the other systems, suggesting that the effects of distance on ridership attrition is just as great as in areas where rail is used more intensively.

4. Impacts of Physical Setting on Rail Modal Splits

Theory tells us that land uses and physical development patterns influence travel choices. This section tests whether such relationships hold for the surveyed sites by presenting several best-fitting regression models that predict rail modal splits as a function of physical characteristics of sites as well as indicators of the quality of the walking environment. Separate models are estimated by pooling data across the 27 surveyed residential sites and the 18 surveyed office sites.

Residential Sites

For the 27 residential sites, two characteristics were found to be the strongest predictors of transit modal splits (for all trip purposes combined) — proximity to the station and residential density. Table 7.3 shows that transit modal splits were, in general, highest for residential projects that were nearest a station and in relatively dense settings. Every one-thousand foot increase in distance to a station, for instance, was associated with a 7 percentage-point decline in rail modal splits, holding density constant. The effect of density was convex-shaped, following a quadratic curve. This is because one of the sites was in a relatively high-density setting yet had a comparatively low rail modal split. (Removing this one case yielded a logarithmic relationship between density and rail modal split.)

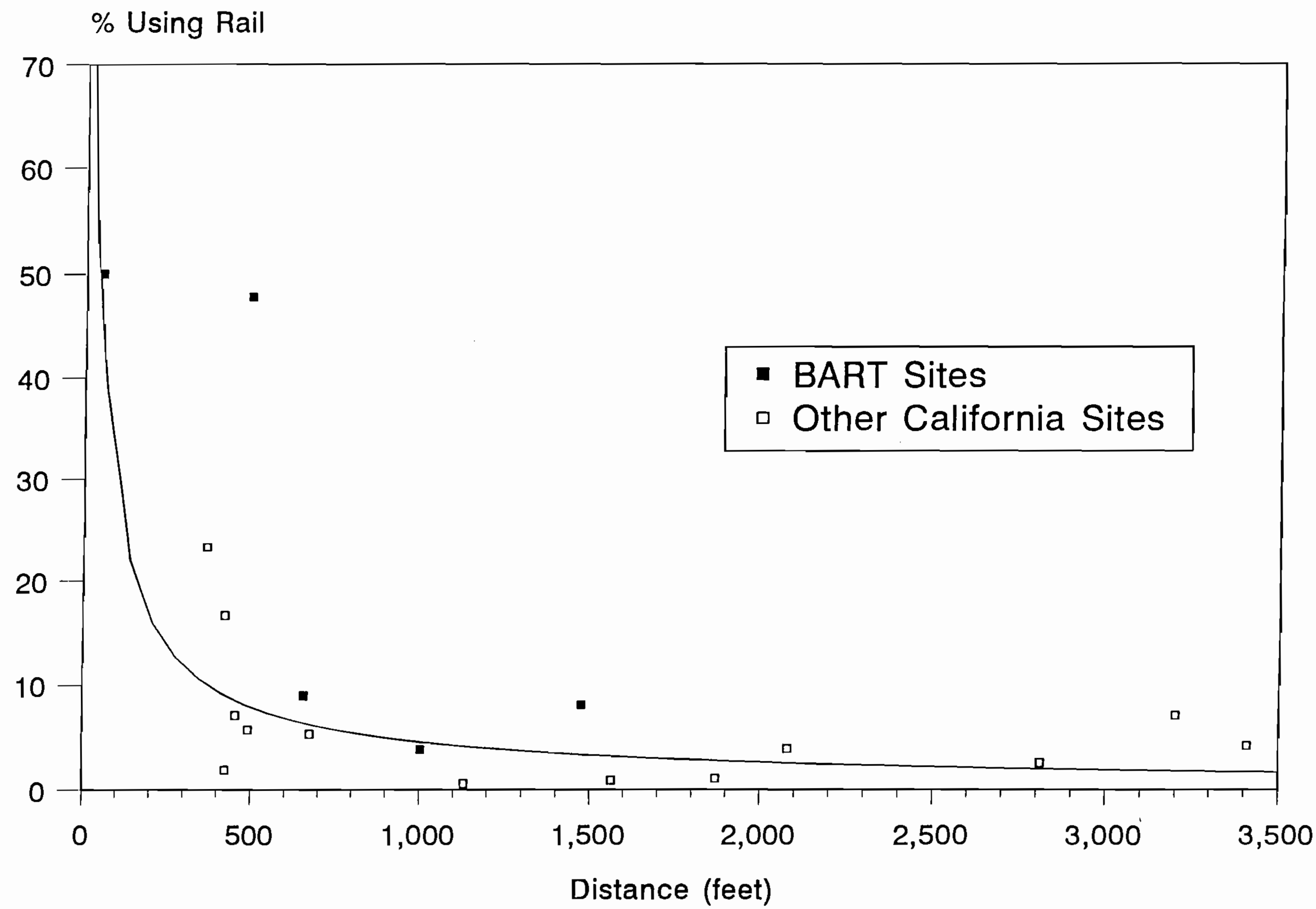
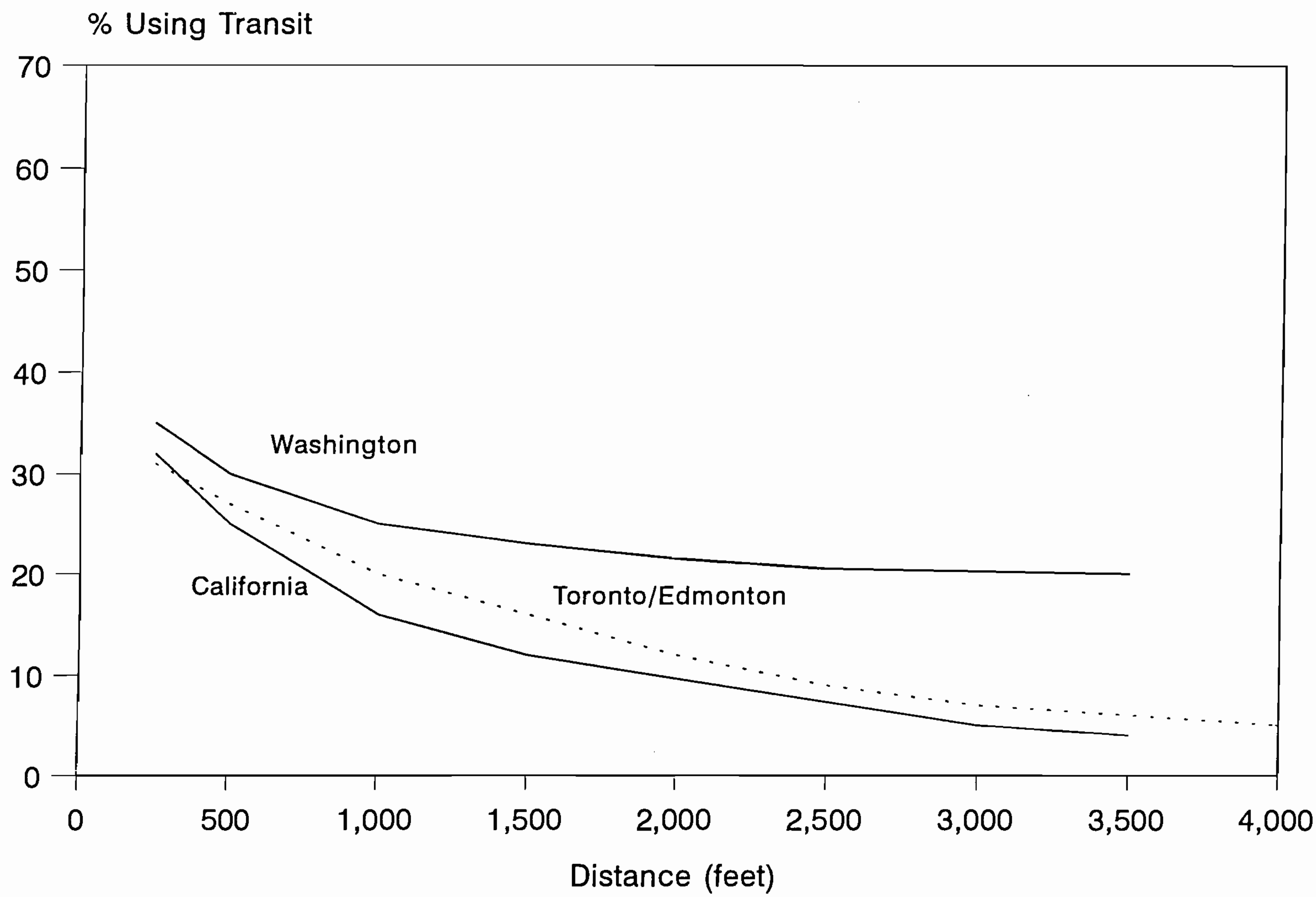


Figure 7.3

Rail Mode Share by Distance to Office Sites, California Systems



Sources: Stringam (1983); JHK (1989)
Note: Washington data includes all transit

Figure 7.4

Rail Mode Share by Distance to Office Sites, Comparison of California and Other Systems

Table 7.3

Significant Predictors of Percent of Trips by Rail Transit Among Residential Sites, All Trips

	Coefficient	Standard Error	Significance
Station Distance(feet)	-0.007	0.0035	0.0593
D.U. per acre	-0.124	0.0064	0.0670
$(\text{D.U. per acre})^2$	1.303	0.6580	0.0620
Constant	4.863	15.1770	0.7604

Summary Statistics:

Number of cases = 27
R-Squared = .303
F = 2.899
Prob = .0604

Overall, the model's fit was not particularly strong, indicating that other explanatory variables accounted for most of the variation in transit modal splits among the 27 sites. Notably, area-wide density was the only land-use-related variable that was a statistically significant predictor. None of the other variables defined in Section 2 of this chapter had any bearing on the share of residents from a site who travelled by rail.

The verdict is clear: besides proximity and density, no other feature of the built environment, including the various metrics used to reflect quality of walking environment, seemed to influence travel behavior of station-area residents. This finding could mean either that other non-land-use-related variables were the significant explainers or that the measures used to gauge attributes of the built environment were deficient. Based on the results of Chapter Four, we believe the results reflect more of the former than the latter. That is, factors like destinations and the availability of free parking are likely far stronger predictors of modal splits that the number of cross-walks passed en route to a station or the existence of varied land uses in the neighborhood. It could be that within a one-quarter- to one-half-mile radius of a station, land uses or features of the built environment matter very little —as long as places are near a station, the characteristics of the immediate surrounding environment are inconsequential.

Office Sites

A better predictive model was found for explaining variation in rail transit modal splits for the 18 office sites near stations. Table 7.4 shows that four variables explained 92 percent of the variation: proximity to station; employment density of the area; commuting behavior at employees' prior jobs; and occupation. The model reveals the following:

Table 7.4

Significant Predictors of Percent of Work Trips by Rail Transit Among Office Sites

	Coefficient	Standard Error	Significance
Station Distance[a]	859.871	122.841	.0000
Employment density[b]	.022	.007	.0089
Prior Rail[c]	.609	.228	.0190
Manager/Professional[d]	.327	.088	.0026
Constant	-10.855	2.752	.0017

Summary Statistics:

Number of cases = 17
R^2 = .921
F = 37.63
Prob = .0000

Notes:

a. The variable for station distance used here was developed in the previous section for the ridership gradient, in the form:

$$(\text{Station distance})^{-.795}$$

so that as the distance to the station increases, the variable decreases.

b. Distance to the nearest freeway on-ramp, measured in miles.

c. The percent of workers at each site who regularly took rail to their previous job.

d. The percent of workers at each site who held managerial or professional positions.

- Ridership decreased at a decreasing rate as the distance from an office to a station increased, as noted in the previous section. Thus, office workers within one block of a station were far more likely to commute by rail transit that those working four or five blocks away.

- The density of the area around the transit station had a positive influence on ridership. For every additional 100 employees per acre, rail ridership rose 2.2 percent. Although this relationship is not astounding, it does follow expectations that with increases in density, transit becomes increasingly attractive over other modes of transportation.

- Being accustomed to commuting by rail appeared to have some bearing on modal splits. For every one percent increase in the share of workers who commuted by rail transit to their previous workplaces, there was a 0.61 percent increase in the share of rail commuting among office workers at their current workplaces. This suggests that old habits sometimes persist— if workers are accustomed to rail commuting, they are slightly more likely than other workers to patronize rail if their current workplace is well-served by rail transit.

- Buildings with a relatively large share of management and professional personnel tended to average higher rail commute modal splits. This is not altogether consistent with expectations, and could reflect a concomitant relationship —managers and professionals tend to be concentrated in downtown offices and urban centers, locales which, because of their densities, mixed uses, and restricted parking, average high transit modal splits. Thus, it is likely that this variable is serving as a proxy for workplaces that are transit-oriented and well served by rail services.

5. Conclusions

Overall, residences and offices closest to California rail stations were found to average higher transit modal splits than places farther away. Thus, proximity was confirmed as an important factor in shaping the travel choices among station-area residents and workers. The relationship between proximity and transit modal splits was not as strong, however, as that found for the Washington, D.C., area or for the two Canadian metropolises— Toronto and Edmonton. Proximity was more important, however, in explaining the travel behavior of California's station-area workers than its station-area residents.

Among land-use variables, only neighborhood density, in addition to proximity, was a significant explainer of modal splits for apartments and other residential buildings near rail stations. None of the indicators of "walking quality", land-use mixture, or other physical attributes of station-areas helped explain modal splits. This could be because proximity, in addition to characteristics of destinations (like proximity to rail and parking restrictiveness), override all other factors.

Proximity played an even stronger role in influencing the commuting behavior of office and factory workers near rail stations. In general, rail usage plummeted as the distance of workplace to the nearest station increased. In contrast, ridership increased slightly but steadily as employment density at office sites increased. Transit modal splits also tended to increase as the share of workers who previously worked near transit and who have executive and professional jobs rose.

In summary, the findings from this analysis suggest that within walking distance of a rail station, the physical characteristics of the surrounding environment matter little in shaping commuting choices (ignoring issues of safety, blightedness, and the like), with the exception of density. Neighborhood density is correlated with higher rates of transit usage for residential developments and employment density is correlated with higher transit commute shares at office developments. Of course, to the degree more projects are sited near rail stations, it follows that densities will increase. We conclude, then, it is the "clustering" of residences and workplaces near rail station that has the biggest influence on travel behavior within a one-quarter- to one-half-mile radius of a station. As long as development is geographically close and oriented toward a rail station, reasonable shares of trips made by residents and workers will be by rail transit.

Notes

[1]For residential sites, two measures of densities were used. The first is the density of the site itself, measured in dwelling units per acre of the site. This was computed by dividing the total number of dwelling units by the total land area of the residential. The second measure of density was the density of the census tract to which the site belonged. This was computed by dividing the total number of dwelling units in the census tract by the total area of developed land devoted to residential uses.

[2]The floor area ratio is the gross floor area of all the buildings divided by the land area of the parcel. For example, a one-story building that completely covers the whole parcel would have a floor area ratio of 1. A two-story building covering half of the parcel would also have a floor area ratio of 1.

[3]The distance to the nearest station was calculated using a device that measures walking distances. For residential sites, distances were measured from a designated centroid to the nearest ticket machine. For office sites, distances were measured from the main entrance to the building (or, in the case of multiple buildings at a site, from a designated centroid) to the nearest ticket machine. Distances were rounded to the nearest ten feet.

[4]The distance from the nearest freeway on-ramp was measured with a ruler on Thomas Brother's maps to the nearest tenth of a mile.

[5]Census tracts were chosen to represent "areawide" characteristics. For the most part, census tracts corresponded to an area representing between a one-half- and one-square-mile area around the rail station.

[6]An entropy index was developed to gauge the degree of land-use mixture in the census tract. The index expressed the degree of heterogeneity across the land-use classes of residential, commercial, industrial, and institutional/public land uses. High entropy values indicated land-use heterogeneity while low values denoted land-use homogeneity. Land area was net of parklands and open spaces.

[7]In addition to measuring the distance along the shortest path between the site and the nearest station, researchers counted the number of street crossings and noted whether the crosswalks were equipped with pedestrian-activated signals or had no signal at all.

[8]The widest street width was measured at the point of crossing from curb to curb, or, where no curbs existed, from one edge of the street pavement to the other.

[9]For office sites, two measures of densities were used. The first was the employment density of the site itself, measured in employees per acre of the site. Employment density was computed by dividing the total number of employees by the total area of the site. The second measure was the employment density of the census tract to which the site belonged. This was computed by dividing the total number of employees in the census tract by the total area of developed land devoted to employment uses.

[10]This was also reflected in the logit models presented in Chapters Four and Five. Walking distance from the site to the nearest rail station was a significant predictor of mode choice for office workers; however, it was insignificant (and thus did not enter the model) for predicting mode choices of station-area residents.

Chapter Eight

Summary, Conclusions, and Prospects

1. Summary

Conventional wisdom holds that apartments, offices, and shopping plazas near rail transit stations average relatively high ridership levels. The primary purpose of this research has been to test this hypothesis for five rail systems in California. The research findings largely confirm the hypothesis —however, with several important caveats. One, both housing and workplaces need to be clustered around rail facilities if significant shares of work trips are to be captured by rail transit; concentrating only one end of the work trip, such as housing, in the absence of substantial clusters of the other end, offices and factories, will unlikely produce high rates of rail commuting. Two, regardless how close development is to a rail station, a number of other factors intervene that strongly determine mode choice. The most important is parking at the workplace. If people living and working near rail stations receive free parking where they work, the odds of commuting by rail drops sharply. And third, transit-focused development, in and of itself, is unlikely to yield substantial secondary benefits, like reduced traffic congestion on parallel corridors or lower levels of air pollution. In combination with other transit-supportive programs, however, transit-focused development can make an important contribution toward the attainment of such regional mobility and environmental goals.

This research was organized around studying ridership characteristics of transit-focused development, and in particular how features of the built environment shape transit demand, for three types of land uses: residential, employment, and commercial-retail. Principle findings of this research are summarized below, by each land-use category.

Transit-Focused Housing

Surveys data were collected from residents of 27 apartments and condominiums (each with at least 75 dwelling units) located within around one-half mile of a rail station. Data were compiled for nearly 900 households, producing around 2,500 trip records.

- The average rail modal split for all trips was 15 percent, with significant variation. Rail shares as high as 79 percent and as low as 2 percent were found among residential projects. Housing around BART averaged the highest rail splits (26.8 percent) while housing around SCCTA averaged the lowest (6.7 percent). Overall, those residing near California rail stations are fairly auto-dependent — over 75 percent relied on a car, either as a driver or a passenger, for their primary trips.
- Rail captured 19 percent of work trips made by station-area residents, and in the case of BART, 33 percent. This is much higher than the three BART-served counties' rail modal split of 5 percent for work trips in 1990. It is also considerably higher than the 1990 average of 17.8 percent for all Bay Area residents living within one-half mile of a BART

station. For each Bay Area city served by BART, residents living near rail stations were around five times as likely to commute by rail transit as the average resident-worker in the same city.

- The strongest predictors of whether station-area residents commuted by rail was whether their destination was near a rail station and whether they could park free at their destination. Other significant predictors were vehicle ownership levels and the availability of employer-paid transit allowances. If station-area residents work in San Francisco for an employer who charges for parking and they receive a transit voucher, there is over a 95 percent chance they will commute by BART. If the same conditions hold and they work in Oakland, the probability falls to 64 percent; and for most other BART-served destinations, the odds are in the 10 to 15 percent range. And if they work at a destination beyond normal walking distance from BART and receive free parking, there is only around a 2 percent chance they will commute by rail. Clearly, if transit-based housing is to produce meaningful mobility and environmental benefits, there must also be transit-focused employment centers.
- Many of those surveyed who previously lived elsewhere in the same metropolitan area, though not near a rail station, changed modes of travel once they moved close to rail—around 29 percent who usually drove alone to work at their previous residence now commute by rail. A majority of current rail users, however, previously rode rail or bus to work. Part of the high incidence of rail commuting among station-area residents, then, could be due to the fact that they have a high proclivity to patronize rail transit. Also, the decision to rent or buy a home near a rail station might have been influenced by a desire to commute to work by rail transit.
- As might be expected, the vast majority of those residing near rail accessed nearby stations by foot — around nine out of ten. Once they reached their exit station, around three-quarters walked to their destinations.
- Households near rail stations were smaller in size (average = 1.89 persons) and owned fewer vehicles (average = 1.53 cars or trucks) than other households in the respective metropolitan areas.

Transit-Focused Worksites

Survey data were gathered from over 1,400 employees at 18 worksites, all located within one-half mile of a California rail station.

- The average rail modal split for work trips was 8.8 percent. For surveyed worksites near BART, rail's share was 17.1 percent, well above the Bay Area's rail work trip share of 5 percent. On average, those working near California rail stations were 2.7 times more likely to commute by rail than the average worker in the cities studied.
- The strongest predictors of whether station-area workers commuted by rail was whether they resided in a rail-served city, could park free at their workplaces, and had access to a private vehicle. Living in a BART-served city, for instance, increased the likelihood of station-area workers commuting by BART by 40 percentage points, all else equal. Free parking reduced the likelihood by around 20 percentage points. Rail commuting also increased with commute distance and the availability of a transit allowance (when combined with paid parking at the workplace). Overall, these findings are consistent with those for transit-based housing— both the origin and destination ends of the commute trip need to be in reasonably close proximity to a station for there to be high levels of rail travel. That is, transit-based workplaces require transit-based housing if rail travel is to seriously compete with the private automobile.
- Of station-area workers who previously worked at a location unserved by rail but within the same metropolitan area, only around 31 percent commuting by rail now used it before. From this, one can infer that working near a rail station raises the likelihood of commuting by rail by 30 or so percentage points, all else being equal.
- Working near rail was not a strong inducement to using rail for midday travel. Only 3 percent of midday trips made by station-area workers were by rail. The need to make

midday trips, on the other hand, reduced the odds that station-area workers commuted by rail.

- Among station-area workers who commuted by rail, slightly more than 50 percent park-and-rode at the originating station. Around one out of five reached the station by foot. Once at their destination station, over 85 percent walked to their nearby workplace.

Transit-Focused Retail Centers

Intercept surveys were conducted of shoppers, employees, and others at three large Bay Area shopping complexes located within a quarter-mile of a BART station. SFCentre is located in the heart of downtown San Francisco's retail district where parking is expensive and transit services are superior to anywhere in the region. Both El Cerrito Plaza and Bayfair shopping center are large enclosed complexes in the East Bay, surrounded by free parking.

- For all three shopping centers combined, 15 percent of those surveyed arrived at the center by BART. The two suburban shopping malls with plentiful parking had lower rail shares, especially El Cerrito where only 6.6 percent of shoppers and others surveyed arrived by BART.
- SFCentre's relatively high share of BART users partly reflects its larger retail market-shed —around 14 percent traveled over 20 miles to get there. However, over one-third also traveled less than a mile to SFCentre— typically downtown workers and tourists.
- Shoppers who arrived by rail tended to be women, youths, and ethnic minorities.

Influences of the Built Environment

The relationships between transit ridership and the site and neighborhood characteristics of the 27 residential and 18 workplaces were also explored.

- Rail's modal share fell linearly with distance from the station for the surveyed housing projects —on average, by about 0.85 percentage point for every 100-foot increase in walking distance.
- For offices, the ridership gradient followed an exponential decay function. For non-BART sites, only offices within 500 feet of a station had as much as 15 percent of their workers commuting by rail; beyond 500 feet, no more than 10 percent of workers took rail to work.
- In general, ridership gradients for California transit-focused projects were flatter and lower than those found in previous studies for Washington, D.C., Toronto, and Edmonton. This is likely attributable to the greater abundance of park-and-ride facilities at California stations, differences in urban form, and the higher degree of workplace primacy (i.e., larger downtowns) in these other cities.
- Among land-use variables studied, ridership for transit-based housing projects was most strongly related to neighborhood density and proximity. Mixed land uses and various indicators of "walking quality" were not significant predictors of transit modals splits among residential sites. Thus, within a one-half mile or so radius of a station, land uses or features of the built environment matter very little— as long as residences are near stations, the characteristics of the immediate surroundings are of minor importance, barring no serious problems like blight or high crime rates.
- For office developments, proximity and area-wide densities were the two dominant site-related factors influencing rail usage. For every additional 100 employees per acre, rail ridership rose 2.2 percent. Mixed uses and measures of environmental and walking

quality were not significant predictors of the share of station-area workers who commuted by rail.

- Overall, it is the "clustering" (i.e., close proximity and higher densities) of residences and workplaces near rail stations that has the biggest influence on travel behavior among all land-use factors. Factors like levels of mixed use or quality of walking environment have a negligible influence. As long as development is geographically close and oriented toward a rail station, reasonable shares of residents and workers will travel by rail. To the degree both ends of trips are clustered around a rail station, the odds of traveling by rail transit increase sharply.

2. Conclusions

The principle conclusion of this research is that if transit-focused development is to reap significant mobility and environmental benefits, then most kinds of trip origins and destinations must be clustered around rail stations. Having transit-based housing does little good if most job growth occurs outside of CBDs or far removed from rail stations— such as in suburban office parks and highway corridors. Likewise, rail-served shopping centers will attract relatively few transit users if most residences and workplaces are not oriented to transit. In short, a variety of urban activities need to be concentrated near transit facilities if significant shares of trips are to be won over to transit, especially given the trend towards decentralization. We can conclude, then, that for rail transit to work effectively, metropolitan areas need a multi-centered urban form that is fed by an efficient transit system —that is, they need to be more like some of the world's most successful transit metropolises, such as Stockholm and Toronto. In addition to clustered development around rail stations, other complementary policies and programs need to be in place— such as universal parking charges and employer-paid transit allowances. Together, transit-focused land-use measures and transportation demand management (TDM) programs are a powerful combination for inducing modal shifts to transit.

Not everyone is so optimistic about the prospects of transit-focused development doing much good. Downs (1992) argues that the permanence of the existing built environment will prevent dramatic gains in density, and that only huge increases in average suburban residential densities would substantially reduce average commute distances and solo-commuting. Even under the most generous assumptions, according to Downs, clustering high-density housing near suburban rapid transit stations would unlikely reduce vehicle-miles traveled (VMT) by any more than 2 percent. Besides, he notes, citing the classic study by Pushkarev and Zupan (1977), commercial and employment densities are more important to increasing transit usage than residential densities.

Simple mathematics suggest that Downs could very well be right. Table 8.1 shows that only 8.9 percent of residents from the three BART-served counties lived within one-half mile of a BART station in 1990 —ranging from 4.5 percent in Contra Costa County to 12.3 percent in San Francisco. Based on 1990 census statistics, only 17.8 percent of these station-area residents commuted by

Table 8.1

Estimated Share of 1990 Commute Trips by Station-Area Residents of the Three BART-Served Counties

	% County Population Within 1/2 Mile of BART Station (1990)	% Work Trips by BART Among Workers Living Within 1/2 Mile of BART Station (1990)	Estimated % Total Commutes by Station-Area Rail Commuters (1990)
Alameda County	9.8	17.3	1.7
Contra Costa County	4.5	11.3	0.5
San Francisco	12.3	25.5	3.1
Three County Total	8.9	17.8	1.6

Source: U.S. Census, STF 3-A.

rail transit —again, less in Contra Costa County and more in San Francisco. (This share is slightly below the 19 percent rail modal split for work trips found for the 27 residential sites surveyed in this study.) This suggests that only 1.6 percent of all commute trips within the three BART-served counties were by station-area rail users. Doubling the number of station-area rail users would have a pretty small impact on current regional commuting and environmental conditions.

The one land-use strategy that to Downs seems to hold the most promise is concentrating jobs in large clusters oriented around rail transit stations. This is consistent with the findings of this research that workplaces in dense settings near rail stations average high shares of transit commuters, especially when parking charges are levied. Still, Downs is skeptical about most land-use initiatives, concluding that there is little political support for them and that the efforts required are "wholly disproportionate to the severity of the problem, the pain it is causing, and the benefits of ending it" (p. 94).

While the benefits of singularly achieving transit-based housing or concentrated employment centers are likely to be modest, the effects of such initiatives in combination can be far more substantial, especially when introduced in combination with parking restraints and other TDM measures. One only has to look to Stockholm to appreciate what is achievable. Stockholm, we would argue, is an appropriate comparison in that Sweden is one of the most affluent countries in the world with a high automobile ownership rate (2.1 persons/vehicle). Moreover, most Swedish cities sit in a large flat forested country and experienced rapid growth following World War II. The stage was set for Sweden's metropolises to easily have followed a highway-oriented development pattern. Yet Europe's most prosperous country took off on a radically different suburbanization path than in America. In Stockholm's case, the key reason for this has been careful coordination of regional transit and land-use planning over the postwar period. In response to urbanization pressures, Stockholm's city council has built a number of satellite new towns over the past three decades, most surrounded by greenbelts and connected to Stockholm by rail. An overriding principle was to distribute industry and offices to satellites roughly in proportion to residential population in order to avoid a "dormitory town environment." These rail-fed new towns were also planned for a mix of housing types (single-family and multi-tenant) as well as uses, with offices, shops, civic buildings, and other activities in close proximity to each other (Hall, 1988; City of Stockholm, 1989).

The mobility and environmental impacts of this built form have been unmistakeable. In 1990, 38 percent of the residents and 53 percent of the workers of these rail-served new towns commuted by rail transit. For all of Stockholm County, rail accounted for 42 percent of all commute trips (Stockholm Läns Landsting, 1992). However, urban development patterns, alone, did not produce these results. Parking and automobile travel is expensive in all Swedish cities, and nearly all apartments are publicly subsidized. Cities like Stockholm are testaments to how integrated rail and land-use planning in combination with market-rate pricing of automobile travel and other demand management efforts can reduce auto-dependency.

3. Prospects and Outlooks

A number of observers hold high prospects for denser, more transit-oriented housing and workplaces in the U.S. According to the Urban Land Institute (ULI) (1991), rising housing costs and the trend toward smaller households — young people just starting out, young married couples saving for a first home, empty nesters, persons once again living alone because of a divorce or death of a spouse —bodes well for the future of multifamily housing. Today, around 30 percent of households with annual incomes in the $20,000-$30,000 range live in multifamily housing. ULI (1991, p. 6) concludes that "a region's economic growth and vitality depend on the presence of a sufficient supply of workers . . . and a region's ability to attract workers depends in large measure on the availability of affordable housing."

Of course, most long-time suburbanites take a dim view toward densification and fight it every step of the way, whether through ballot-box zoning or voting NIMBY-sensitive politicians into local office. Many developers follow the fundamental rule that "as density goes up, the general interest from the consumer goes down" (Bookout, 1992: 15). Some designers argue that increased densities are possible if they are complemented by more amenities, such as on-site recreational facilities, on-site water features and civic spaces, pedestrian-friendly streets, and human building scales. Some designers also maintain they can change peoples' "perceived densities" through such treatments as: varying building heights, detailing rooflines, and altering building materials to break the monotony of traditional slab structures; narrowing setbacks while maintaining detached units; adding accessory units and granny flats to backlots; converting single-family homes into duplexes and triplexes; and designing buffers and edges around high rises (Bookout and Wentling, 1988).

Most cities also have a number of tools at their disposal to encourage infill development and higher densities: land use controls (e.g., density bonuses, transferable development rights); formation of redevelopment authorities; and various taxing devices (e.g., tax increment financing). Tranit investments themselves can be effective levers toward inducing higher density growth, particularly if they occur during a period of bouyant economic growth (Cervero et al., 1992). And of course efficient pricing of resources, whether road space or clean air, would over the long run work toward more concentrated urban growth. One variation of efficient pricing would be to grant credits of various forms —such as against property taxes and impact fee obligations— to developments that are conducive to transit riding, ridesharing, walking, and bicycling. If transit-focused development indeed yields public benefits, as has been the case in Stockholm, then this "positive" impact should be financially rewarded —the opposite of an impact fee. Better pricing and better urban design, along with better regional planning, would go a long way toward producing built forms that begin to attract substantial numbers of Americans to transit and other alternatives to the drive-alone automobile.

Appendix A

Residential Survey

BAY AREA TRAVEL SURVEY

This survey is part of a continuing effort to improve transportation services in the Bay Area. It is being conducted by the University of California Transportation Center. Please help us by filling out this questionnaire. Your responses will be completely confidential. Please complete this *within one week* and drop it in any mailbox. Postage is prepaid. For questions, please contact Barbara Hadenfeldt at UC Berkeley (510) 642-4874.

** Thank You for Your Time and Assistance **

Information on Your Household

1. Including yourself, how many people live in your household: ________ How many 16 years or older: ________
2. How many autos, pickups, and vans are available for use by members of your household: ________

Information on Persons 16 Years of Age or More

Please provide information on up to two household members of at least 16 years of age, including yourself and one other person.

	You	Person 2
3. Sex: 1 = Female 2 = Male (enter 1 or 2)	______	______
4. Age of each person	______	______
5. Ethnicity or race	______	______
6. Does person work outside this residence? (enter 1, 2, or 3) 1 = Yes, Full-Time 2 = Yes, Part-Time 3 = No	______	______
7. For persons working, enter code to indicate current occupation:	______	______
8. Approximate annual salary (enter code):	______	______

Occupation codes (7):

1 = Accounting/Financial
2 = Clerical/Secretarial
3 = Craftsman (mechanic, builder)
4 = Laborer
5 = Manager/Administrator
6 = Professional (consultant, engineer)
7 = Sales Worker
8 = Service Worker (waiter, store clerk)
9 = Other (specify)

Salary codes (8):

1 = 0-$15,000
2 = $15,001-$20,000
3 = $20,001-$25,000
4 = $25,001-$30,000
5 = $30,001-$40,000
6 = $40,001-$50,000
7 = $50,001-$60,000
8 = $60,001-$70,000
9 = $70,001-$80,000
10 = over $80,000

9. Travel of Persons 16 Years of Age or More

Please provide travel information on each person identified in the previous section. Person 2 in the previous section should be the same as Person 2 in this section. For each person, please provide data for the main trips made yesterday. (If yesterday was Saturday or Sunday, please fill in for the last weekday you worked.)

• Please use the codes below to fill in information on Trip Purpose and Means of Travel: •

YOU (Date: ___/___/92)

	Trip 1	Trip 2	Trip 3
Time you left (circle AM or PM)	___:___ AM/PM	___:___ AM/PM	___:___ AM/PM
Trip Purpose (use codes below)	______	______	______
Means of Travel (use codes below)	______	______	______
Origin (city name or zip code)	______	______	______
Destination (city name or zip code)	______	______	______
Arrival time at Destination	___:___ AM/PM	___:___ AM/PM	___:___ AM/PM
Length of trip	______ miles	______ miles	______ miles

PERSON 2 (Date: ___/___/92)

	Trip 1	Trip 2	Trip 3
Time you left (circle AM or PM)	___:___ AM/PM	___:___ AM/PM	___:___ AM/PM
Trip Purpose (use codes below)	______	______	______
Means of Travel (use codes below)	______	______	______
Origin (city name or zip code)	______	______	______
Destination (city name or zip code)	______	______	______
Arrival time at Destination	___:___ AM/PM	___:___ AM/PM	___:___ AM/PM
Length of trip	______ miles	______ miles	______ miles

CODES:

TRIP PURPOSE CODES:

1 = Go to Work
2 = Return Home
3 = Personal Business (e.g., to bank)
4 = Meal or snack
5 = Shopping
6 = Medical
7 = Social/Recreational
8 = Other (__________)

MEANS OF TRAVEL CODES

1 = Drove a car
2 = Rode in a car or van
3 = BART
4 = Rode Bus
5 = Walk
6 = Bicycle
7 = Other (__________)

COMPLETE BOTH SIDES
THEN FOLD AND SEAL WITH TAPE

Information on Commuting (YOU only)

Please answer the remaining questions only for you.

10. What was your round-trip cost to and from work for:

transit fares $ ____.___ parking $ ____.___
tolls $ ____.___ others $ ____.___ (specify: ____________)

11. Does your employer: (Check all that apply)

Help pay for your transit expenses ______ Stagger your work hours ______
Allow you to work flexible hours ______ Provide a car for business or emergency use during the day ______

Provide free parking ______ If not, how much is parking: per day $____.___
per month $____.___

Information on Commuting by BART (YOU only)

Answer *only for yourself, and only if you rode BART for any portion of your trip to work*. Otherwise skip questions 12 and 13.

12A. At which BART station did you board from on your way to work: ____________
At which BART station did you exit from on your way to work: ____________

12B. How did you get from your home to BART and then from BART to your workplace:

From home to BART (check one)	From BART to Workplace (check one)
walk ______	walk ____
drive car ______	drive car ____
ride as passenger _____	ride as passenger _____
bus _____	bus ____
bicycle _____	bicycle ____
other (________) _____	other (_______) ____

12C. How long did it take you to travel from:
Your home to BART ______ mins. BART to your workplace ______ mins.

Please provide the requested information for your prior residence if your prior residence was in the Bay Area:

13A. City or zip code of prior residence: ______________

13B. For your prior residence, did you work at the same place as you do now? Yes _____ No _____
If you answered No, please indicate the city or zip code where you last worked when you lived in your prior residence:
____

13C. On most days, what was your usual means of travel to work: (Check one)

____ Drove a car ____ Rode Bus ____ Other (____________)
____ Rode in a car or van ____ Walk
____ BART ____ Bicycle

13D. What was the usual amount of time and distance to work from your previous residence: ______ minutes______miles

General Comments

Please provide any comments or suggestions on how transportation might be improved in the Bay Area:

____

____

____

____

If you are willing to take part in a more extensive transportation/housing survey please provide your name and number below:

NAME: ______________________________TELEPHONE: (_____) ______--______

VR 35

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL

FIRST-CLASS MAIL PERMIT NO. 7 BERKELEY, CA

POSTAGE WILL BE PAID BY ADDRESSEE

INSTITUTE OF URBAN AND REGIONAL DEVELOPMENT
UNIVERSITY OF CALIFORNIA
2000 CARLTON ST
BERKELEY CA 94704-9978

Appendix B

Office Survey

BAY AREA TRAVEL SURVEY

This survey is part of a continuing effort to improve transportation services in the Bay Area. It is being conducted by the University of California Transportation Center. Please help us by filling out this questionnaire. Your responses will be completely confidential. Please complete this *within one week* and drop it in any mailbox. Postage is prepaid. For questions, please contact Barbara Hadenfeldt at UC Berkeley (510) 642-4874.

Information on Yourself

1. Please indicate where you live
   Name of City or Town: ______________________ Intersection nearest your home: ______________________
   Zip Code:__________
2. Including yourself, how many people live in your household? ____________
3. How many autos, pickups, and vans are available for use by members of your household? ____________
4. Your sex: (Circle one) 1 = Female 2 = Male
5. Your age: __________
6. Your occupation: (Circle one)
   1 = Accounting/Financial
   2 = Clerical/Secretarial
   3 = Craftsman (e.g., mechanic, builder)
   4 = Laborer
   5 = Manager/Administrator
   6 = Professional (e.g., consultant, engineer, lawyer)
   7 = Sales Worker
   8 = Service Worker (e.g., waiter, store clerk)
   9 = Other: (________________________)
7. Your approximate annual salary: (Circle one)
   1 = 0-$15,000
   2 = $15,001-$20,000
   3 = $20,001-$25,000
   4 = $25,001-$30,000
   5 = $30,001-$40,000
   6 = $40,001-$50,000
   7 = $50,001-$60,000
   8 = $60,001-$70,000
   9 = $70,001-$80,000
   10 = over $80,000

Your Commute Characteristics Please provide information on your *trip to work today.*

8. Today's date: ___/___/92
9. At what time did you leave home to go to work? _____:_____ AM/PM (circle AM or PM)
   At what time did you arrive at work? _____:_____ AM/PM
10. What means of travel did you use to get to work *today?* (Circle one)
    1 = Drove alone
    2 = Drove with others (how many others, excluding yourself ____)
    3 = Rode as a passenger (how many total were in vehicle ____)
    4 = Rode BART
    5 = Rode Bus
    6 = Walked entire way
    7 = Bicycled
    8 = Taxi
    9 = Other (specify: ________________)
11. Approximate travel distance from your home to your office: ________ miles

— Answer Part A or B, whichever applies —

A. Information on Driving to Work

Answer these questions only if you *drove to work today.* Otherwise skip to question 15.

12. Are there convenient transit connections available for your trip to work? (Circle one) 1 = Yes 2 = No 3 = Don't Know
13. Did you or will you need to use your car during the day *today?* 1 = Yes 2 = No
14. Does your employer: (Check all that apply)
    Help pay for your transit expenses ______
    Stagger your work hours ______
    Provide free parking ______
    (*If not,* how much is parking: per day $_____ per month $_____)
    Allow you to work flexible hours ______
    Provide a car for business purposes during the day ______

B. Information on Commuting by BART

Answer these questions *only if you rode BART for any portion of your trip to work today.* Otherwise skip to question 20.

15. At which BART station did you board on your way to work: __________
    At which BART station did you exit on your way to work: __________
16. On your way to work, how did you get from your home to BART and then from BART to your workplace:

From Home to BART (check one)		From BART to Workplace (check one)	
walk	______	walk	______
drive car	______	drive car	______
ride as passenger	______	ride as passenger	______
bus	______	bus	______
bicycle	______	bicycle	______
Other (________)	______	Other (_______)	______

17. How long did it take to travel from: Your home to Boarding Station _____ mins. Exit Station to your work place. _____ mins.
18. What was your round-trip cost to and from work for: transit fares $___.___ parking $___.___ tolls $___.___
    other (specify:________________________) $___.___
19. Does your employer: (Check all that apply)
    Help pay for your transit expenses ______
    Stagger your work hours ______
    Provide free parking ______
    (*If not,* how much is parking: per day $_____ per month $_____)
    Allow you to work flexible hours ______
    Provide a car for business purposes during the day ______

COMPLETE BOTH SIDES
THEN FOLD AND SEAL WITH TAPE

20. **Midday Trips**

Did you make any trips outside your building yesterday during work hours? _____ yes _____ no

If you answered yes, please fill in the requested information below.

Midday Trips You Made Yesterday:

	Trip 1	Trip 2
Time you left	____:____ AM/PM	____:____ AM/PM
Trip Purpose (use codes below)	________	________
Means of Travel (use codes below)	________	________
Destination(city name or zip code)	________	________
Arrival time to destination	____:____ AM/PM	____:____ AM/PM
Length of trip	________ miles	________ miles

CODES:

TRIP PURPOSE CODES	MEANS OF TRAVEL CODES
1 = Business-related	1 = Drove a car
2 = Personal Business (e.g., to bank)	2 = Rode in a car or van
3 = Meal or snack	3 = BART and walk
4 = Shopping	4 = BART and drive
5 = Medical	5 = BART and bus
6 = Social/Recreational	6 = Bus only
7 = Other *(write in)*	7 = Walk
	8 = Bicycle
	9 = Other *(write in)*

Prior Commuting

Please provide the requested information for your prior place of work *if you worked at a different location in the BAY AREA within THE LAST THREE YEARS.* Otherwise skip questions 21-24.

21. Your prior place of work:
    Name of City or Town: ________________ Zip Code: ____________
    Nearest Street Intersection: ____________
22. Did you live at the same place then as you do now? Yes _____ No _____
    If you answered No, please indicate the city or zip code where you last lived when you worked at your prior place of work:
    ____
23. On most days, what was your usual means of travel to work: (Check one)
    ____ Drove a car ____ Rode in a car or van ____ BART and walk
    ____ BART and drive ____ BART and bus ____ Bus only
    ____ Walk ____ Bicycle ____ Other (__________)
24. What was the normal amount of time and distance it took to commute to your prior workplace:
    ______ minutes ______ miles

General Comments

Please provide any comments or suggestions on how transportation might be improved in the Bay Area:

____

____

____

____

THANK YOU

VR 35

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL

FIRST-CLASS MAIL PERMIT NO. 7 BERKELEY, CA

POSTAGE WILL BE PAID BY ADDRESSEE

INSTITUTE OF URBAN AND REGIONAL DEVELOPMENT
UNIVERSITY OF CALIFORNIA
2000 CARLTON ST
BERKELEY CA 94704-9978

Appendix C

Pedestrian Intercept Survey

<u>Pedestrian Intercept Survey for Retail Sites</u>

Excuse me. We're from the University of California, Berkeley, conducting a travel survey of shopping centers in the Bay Area. Could I ask you a few brief questions?

Site Name: ______________ **Location of Interview:** ______________
Begin Time: ______________ **End Time:** ____________ **Weather:** ____________
Surveyer: ______________ **Date:** ______________

(1) Your Arrival Time P=PM A=AM	(2) Why are you here: 1. Shopping 2. Eating 3. Business 4. Employee 5. Banking 6. Other	(3) What's your home zip code:	(4) How did you get here: Auto: 1.Driver 2.Passenger 3.Drop off 4.Walk 5.BART 6.Bus 7.Taxi 8.Cycle 9.Other	(5) Did you have a car available for your trip?: 1.Yes 2.No	(6) Where was your last stop before coming here? City, name of building, zip code, nearby intersection	(7) Was this: 1.An office 2.Your home 3.Friend's home 4.Store 5.Bank 6.Restaurant 7.School 8.Hotel 9.Medical 10.Pickup/Drop off 11.Other	(8) How far is that from here? (miles)	(9) How do you rate BART services where 1=very poor & 10=excellent	(10) Gender 1=Female 2=Male	(11) Ethnicity 1=White 2=Black 3=Asian 4=Hispanic 5=Other	(12) Approximate Age: 1=<18 2=18-24 3=25-30 4=31-45 5=46-60 6=>60

Table A4.1

Modal Split Among BART Residential Sites, All Trips and Work Trips

	Percent of Trips by Mode:					
	Drive/ Ride Car	Rail	Bus	Walk	Other	No. of Cases
Bayfair East						
All Trips	58.1	19.4	9.7	12.9	0.0	31
Work Trips	55.6	22.2	11.1	11.1	0.0	
The Foothills						
All Trips	66.2	26.6	2.4	1.6	3.2	124
Work Trips	62.8	30.9	2.1	2.1	2.1	
The Hamlet						
All Trips	50.0	35.7	0.0	14.3	0.0	24
Work Trips	41.7	41.7	0.0	16.7	0.0	
Mission Heights						
All Trips	86.0	10.0	4.0	0.0	0.0	50
Work Trips	80.6	12.9	6.5	0.0	0.0	
Mission Wells						
All Trips	82.5	14.5	1.5	0.8	0.8	131
Work Trips	80.0	17.0	2.0	0.0	1.0	
Nobel Tower						
All Trips	16.6	16.7	41.7	25.0	0.0	22
Work Trips	23.3	10.0	66.7	0.0	0.0	
Park Regency						
All Trips	62.9	31.5	4.0	1.6	0.0	124
Work Trips	57.9	36.8	3.2	2.1	0.0	
Parkside						
All Trips	72.7	18.2	0.0	9.1	0.0	33
Work Trips	73.3	20.0	6.0	6.7	0.0	
Summerhill Terrace						
All Trips	84.0	16.0	0.0	0.0	0.0	25
Work Trips	78.9	21.1	0.0	0.0	0.0	
Verandas						
All Trips	69.1	25.8	1.0	3.1	1.0	97
Work Trips	65.0	30.0	1.3	2.5	1.3	
Wayside						
All Trips	51.0	45.0	0.7	3.3	0.0	151
Work Trips	41.0	54.9	6.0	4.0	0.0	

Table A4.2

Modal Split Among SCCTA Residential Sites, All Trips and Work Trips

	Percent of Trips by Mode: Drive/ Ride Car	Rail	Bus	Walk	Other	No. of Cases
Bella Vista						
All Trips	93.4	3.4	0.0	0.9	2.3	348
Work Trips	92.9	3.6	0.0	0.4	3.2	
Park Almaden						
All Trips	77.3	17.5	0.0	0.0	5.2	97
Work Trips	72.8	15.4	0.0	3.8	0.0	
Stonegate Circle						
All Trips	77.1	20.0	0.0	2.9	0.0	35
Work Trips	80.8	15.4	0.0	3.8	0.0	
Willow Glen Creek						
All Trips	90.8	2.3	0.0	0.0	6.9	87
Work Trips	89.0	3.1	0.0	0.0	7.8	

Table A4.3

Modal Split Among CalTrain Residential Sites, All Trips and Work Trips

	Percent of Trips by Mode: Drive/ Ride Car	Rail	Bus	Walk	Other	No. of Cases
Grosvenor Park						
All Trips	93.1	4.5	0.0	2.3	0.0	44
Work Trips	88.0	8.0	0.0	4.0	0.0	
Hillsdale Garden						
All Trips	78.6	6.1	7.7	4.6	3.1	51
Work Trips	78.3	6.7	6.7	4.5	3.7	
Northpark						
All Trips	66.2	27.0	4.1	2.7	0.0	74
Work Trips	61.1	37.0	1.9	0.0	0.0	
Palo Alto						
All Trips	62.5	2.1	2.1	29.2	4.2	48
Work Trips	66.7	0.0	0.0	20.0	13.3	

Table A4.4

Modal Split Among Sacramento RT Residential Sites, All Trips and Work Trips

	Percent of Trips by Mode: Drive/ Ride Car	Rail	Bus	Walk	Other	No. of Cases
Oaktree						
All Trips	17.9	78.6	3.6	0.0	0.0	28
Work Trips	9.1	86.4	4.5	0.0	0.0	
Windsor Ridge						
All Trips	85.0	11.7	0.0	1.7	1.7	60
Work Trips	84.2	13.2	0.0	2.6	0.0	
Woodlake Close						
All Trips	80.0	12.7	0.0	5.5	1.8	55
Work Trips	74.3	14.3	0.0	8.6	2.9	
Woodlake Village						
All Trips	84.0	5.7	4.3	1.0	5.0	300
Work Trips	86.1	9.4	1.7	1.1	1.7	

Table A4.5

Modal Split Among San Diego Trolley Residential Sites, All Trips and Work Trips

	Percent of Trips by Mode: Drive/ Ride Car	Rail	Bus	Walk	Other	No. of Cases
La Mesa Village						
All Trips	85.9	7.7	0.0	6.4	0.0	78
Work Trips	81.4	9.3	0.0	9.3	0.0	
Park Grossmont						
All Trips	93.2	2.8	0.0	2.0	2.0	37
Work Trips	98.0	2.0	0.0	0.0	0.0	
Spring Hill						
All Trips	64.9	35.1	0.0	0.0	0.0	37
Work Trips	46.2	7.7	46.2	0.0	0.0	
Village of La Mesa						
All Trips	87.0	10.8	0.9	0.9	0.5	222
Work Trips	85.6	11.8	0.7	1.3	0.7	

Table A4.6

Modal Splits for Work Trips by BART Station-Area Residents, by Destination

Mode	San Fran-cisco	Oak-Land	Berkeley/ Albany	Walnut Creek/ Pleas-ant Hill	San Leandro Hayward	Fremont/ Union City	All Other	Share of All Trips
	Destination							
Auto	10.6%	53.8%	35.7%	52.3%	70.3%	80.4%	89.7%	62.1%
Rail	88.1	40.4	57.1	38.7	18.6	16.1	6.0	31.7
Other	1.3	5.8	7.2	9.0	11.1	3.5	4.3	6.2
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Share of Work Trips	13.8%	8.6%	2.3%	18.3%	19.4%	18.4%	19.2%	100.0

Note: The body of this table shows the percent of all trips to each destination made by each mode. The bottom row shows the percent of all trips by station-area residents destined to jurisdictions. The last column shows the percent of all trips by station-area residents by each mode.

Table A4.7

Modal Splits for Work Trips by SCCTA Station-Area Residents, by Destination

Modes	San Jose	Silicon Valley[1]	Palo Alto/ Stanford	All Other	Share of all Trips
	Destination				
Auto	78.6%	93.5%	92.8%	91.3%	87.9%
Rail	15.9	3.0	1.2	0.9	7.2
Other	5.5	3.5	6.0	7.8	4.9
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Share of All Trips	35.8%	49.4%	3.5%	11.3%	100.0%

NOTE: The body of this table shows the percent of all trips to each destination made by each mode. The bottom row shows the percent of all trips by station-area residents destined to jurisdictions. The last column shows the percent of all trips by station-area residents by each mode.

[1]Silicon Valley = Mountain View, Santa Clara, Sunnyvale.

Table A4.8

Modal Splits for Work Trips by CalTrain Station-Area Residents, by Destination

Mode	Destination: San Francisco	Brisbane/ SFO	San Mateo/ Redwood City	Palo Alto/ Menlo Park	All Other	Share of all Trips
Auto	48.3%	81.1%	79.3%	65.0%	83.3%	74.7%
Rail	48.3	16.2	4.3	10.0	12.5	13.3
Other	3.4	2.7	16.4	25.0	9.2	12.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Share of All Trips	12.8%	16.4%	51.3%	8.8%	10.7%	100.0%

Note: The body of this table shows the percent of all trips to each destination made by each mode. The bottom row shows the percent of all trips by station-area residents destined to jurisdictions. The last column shows the percent of all trips by station-area residents by each mode.

Table A4.9

Modal Splits for Work Trips by Sacramento RT Station-Area Residents, by Destinations

Mode	Destination: Sacramento	All Other	Share of All Trips
Auto	75.6%	95.4%	78.8%
Rail	18.4	2.6	16.1
Other	6.0	2.0	5.1
TOTAL	100.0%	100.0%	100.0%
Share of Work Trips	85.7%	14.3%	100.0%

Table A4.10

Modal Splits for All Trips by San Diego Trolley Station-Area Residents, by Destination

	Destination				
Modes	San Diego	El Cajon/ La Mesa	Chula Vista/ National City	All Other	Share of all Trips
Auto	75.6%	85.2%	80.0%	98.4%	82.5%
Rail	23.2	9.6	18.0	0.8	14.0
Other	1.2	5.2	2.0	0.8	2.5
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Share of All Trips	34.9%	57.4%	2.6%	5.1%	100.0%

NOTE: The body of this table shows the percent of all trips to each destination made by each mode. The bottom row shows the percent of all trips by station-area residents destined to jurisdictions. The last column shows the percent of all trips by station-area residents by each mode.

References

Beimborn, E., and H. Rabinowitz. 1991 . *Guidelines for Transit Sensitive Suburban Land Use Design*. Washington, D.C.: Federal Transit Administration, U.S. Department of Transportation.

Bernick, M., and M. Carroll. 1991. *A Study of Housing Built Near Rail Transit Stations: Northern California Experiences.* Berkeley, California: Institute of Urban and Regional Development, University of California at Berkeley, WP No. 546.

Bernick, M., P. Hall, and R. Schaevitz, with M. Carroll, S. Guhathakurta, A. Jadeja, and J. Munkres. 1993. *Planning Strategies for High-Density Housing Near Rail Transit Stations in Northern California. CPS Brief* 5, 2: 1-5.

Bernick, M., and J. Munkres. 1992. *Designing Transit-Based Communities.* Berkeley, California: Institute of Urban and Regional Development, University of California at Berkeley, WP No. 581.

Bookout, L. 1992. "The Future of Higher-Density Housing." *Urban Land* 51(9): 14-18.

Bookout, L., and J. Wentling. 1988. "Density by Design." *Urban Land Institute* 47: 10-15.

Cameron, M. 1991. *Transportation Efficiency: Tackling Southern California's Air Pollution and Congestion*. Los Angeles: Environmental Defense Fund and the Regional Institute of Southern California.

Cervero, R. 1986. *Suburban Gridlock*. New Brunswick: Rutgers University Press.

____. 1989. *America's Suburban Centers: The Land Use-Transportation Link*. Boston: Unwin-Hyman.

____. 1993a. "Assumptions for Evaluating Travel Demand Impacts of Land Use Related TCMs for the Houston-Galveston Region." Newport Beach, California: SR Associates, working paper.

____. 1993b. "Surviving in the Suburbs: Transit's Untapped Frontier. *Access* 2: 29-33.

Cervero, R., P. Hall, and J. Landis. 1992. *Transit Joint Development in the United States: A Review and Evaluation of Recent Expeiences and an Assessment of Future Potential*. Washington, D.C.: U.S. Department of Transportation; and Berkeley: Institute of Urban and Regional Development, University of California at Berkeley, Monograph No. 42.

Cervero, R., and J. Landis. 1992. "Suburbanization of Jobs and the Journey to Work: A Submarket Analysis of Commuting in the San Francisco Bay Area." *Journal of Advanced Transportation* 26(3): 275-97.

City of Stockholm. 1989. *The Development of Stockholm*. Stockholm.

Douglas, B. 1992. *Comparison of Commuting Trends Between Downtown, Suburban Centers, and Suburban Campuses in the Washington Metropolitan Area*. Washington, D.C.: Parsons-Brinckerhoff-Quade-Douglas, Mimeo.

Downs, A. 1992. *Stuck in Traffic: Coping with Peak-Hour Traffic Congestion*. Washington, D.C.: Brookings Institution.

Fehrs and Peers Associates. 1992. *Metropolitan Transportation Commission Bay Area Trip Rate Survey Analysis*. Oakland: Metropolitan Transportation Commission.

Fruin, J. 1992. "Designing for Pedestrians." In *Public Transportation in the United States*, G. Gray and L. Hoel, eds., Englewood Cliffs, New Jersey: Prentice-Hall, pp. 188-204.

Fulton, P. 1986. "Changing Journey-to-Work Patterns: The Increasing Prevalence of Commmunting Within Suburbs in Metropolitan Areas." Washington, D.C.: Paper presented at the Annual Meeting of the Transportation Research Board.

Gomez-Ibanez, A. 1991. "A Global View of Automobile Dependence." *Journal of the American Planning Association* 57(3): 376-79.

Gordon, P., and Richardson, H. 1989. "Gasoline Consumption and Cities: A Reply." *Journal of the American Planning Association* 55(2): 342-45.

Hall, P. 1988. *Cities of Tomorrow: An Intellectual History of Urban Planning and Design in the Twentieth Century*. Oxford: Basil Blackwell.

Handy, S. 1992. *Regional Versus Local Accessibility: Implications for Non-Work Travel*. Berkeley: University of California, doctoral dissertation.

Harvey, G. 1990. *Relation of Residential Density to VMT Per Resident.* Oakland: Metropolitan Transportation Commission.

Holtzclaw, J. 1990. "Manhattanization versus Sprawl. How Density Impacts Auto Use Comparing Five Bay Area Communities." *Proceedings of the Eleventh International Pedestrian Conference*. Boulder, Colorado: City of Boulder, pp. 99-106.

Hooper, K. *Travel Characteristics at Large-Scale Suburban Activity Centers*. Alexandria, Virginia: JHK & Associates, NCHRP Project 3-38(2), Transportation Research Board, National Research Center.

Hu, P., and J. Young. 1992. *Summary of Travel Trends: 1990 Nationwide Personal Transportation Survey*. Washington, D.C.: Federal Highway Administration, U.S. Department of Transportation.

JHK and Associates. 1987. *Development-Related Ridership Survey I*. Washington, D.C.: Washington Metropolitan Area Transit Authority.

____. 1989. *Development-Related Ridership Survey II*. Washington, D.C.: Washington Metropolitan Area Transit Authority.

Lerner-Lam, E., S. Celniker, G. Halbert, C. Chellman, and S. Ryan. 1992. "Neo-Traditional Neighborhood Design and Its Implications for Traffic Engineering." *ITE Journal* (January): 17-24.

MNCPPC — Maryland National Capital Park and Planning Commission. 1992. *Transit and Pedestrian Oriented Neighborhoods*. Silver Spring: MNCPPC.

Metropolitan Transportation Commission. 1992. *Bay Area Travel and Mobility Characteristics: 1990 Census, Working Paper #2*. Oakland: Metropolitan Transportation Commission.

____. 1993. *Journey-to-Work in the San Francisco Bay Area, Working Paper #5*. Oakland: Metropolitan Transportation Commission.

Newman, P., and Kentworthy, J. 1989. "Gasoline Consumption and Cities: A Comparison of U.S. Cities with a Global Survey." *Journal of the American Planning Association* 55(1): 24-37.

Pill, J. 1983. "Emerging Suburban Activity Centers in Metropolitan Toronto." *Journal of Advanced Transportation* 17(3): 301-315.

Pisarski, A. 1992. *Travel Behavior Issues in the 90's*. Washington, D.C.: Federal Highway Administration, U.S. Department of Transportation.

Pivo, G. 1993. "A Taxonomy of Suburban Office Clusters: The Case of Toronto." *Urban Studies* 30(1): 31-49.

Pushkarev, B., and J. Zupan. 1977. *Public Transportation and Land Use Policy*. Bloomington: Indiana University Press.

Rice Center for Urban Mobility Research. 1987. *Houston's Major Activity Centers and Worker Travel Behavior*. Houston: Houston-Galveston Area Council.

Sedway and Associates. 1989. *BART Higher Density Residential Study*. San Francisco: Sedway and Associates, mimeo.

Stockholms Stadsbyggnadskontor. 1972. *Stockholm Urban Environment*. Uppsala: Almquist and Wiksells, Boktrykeri AB.

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

Untermann, R. 1984. *Accommodating the Pedestrian: Adating Towns and Neighborhoods for Walking and Bicycling*. New York: Van Nostrand Reinhold.

Urban Land Institute. 1991. *The Case for Multifamily Housing*. Washington, D.C.: Urban Land Institute.