Monograph 48

Rail Transit Investments, Real Estate Values, and Land Use Change:

A Comparative Analysis of Five California Rail Transit Systems

John Landis, Subhrajit Guhathakurta, William Huang, and Ming Zhang

with Bruce Fukuji and Sourav Sen

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University of California at Berkeley
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Executive Summary

Transportation systems are the glue that binds together American cities. From the first boulevard, through the horse-drawn streetcars of the 19th Century, through the electric trolleys of the early 1900s, to the freeways of the post-World War II era, transportation investments have long played a defining role in guiding the growth and development of metropolitan areas. What is today called the "transportation-land use connection" has been the object of study by geographers and economists for more than 150 years, and the focus of attention for developers and speculators for even longer.

This report explores the transit-land use connection from the transit side. Drawing on data for five urban rail transit systems here in California (BART, CalTrain, Sacramento Light Rail, the San Diego Trolley, and Santa Clara Light Rail), it uses statistical models to clarify the relationships between transit investments, land uses, and property values. Four types of transit-land use/property value relationships are considered:

- Relationships between rail transit investments and single-family home prices;
- Relationships between rail transit investments and commercial property values;
- Relationships between rail transit investments and station area land use changes; and,
- Relationships between rail transit investments and metropolitan-scale land use changes

The Policy Context

This report responds to two policy questions. The first is fiscal in nature; the second relates to issues of development policy.

1. *New Sources of Local Revenue*: Urban rail transit systems across the country are facing significant fiscal stresses. Capital and operating costs are increasing even as ridership continues to decrease. Transit operating assistance is likely to be significantly reduced or perhaps even eliminated by a Congress hostile to government subsidies in general, and to urban transit subsidies in particular. As operating shortfalls rise, transit operators will increasingly be forced to turn to their ridership base (in the form of higher fares) or to friendly state and local governments for operating assistance.

Benefit assessment districts are one possible alternative source of financing. To the extent that the benefits associated with rail transit systems (and their use) accrue to a broader section of the population than just transit-riders (who presumably pay for the benefits they receive through fares), it may be possible to "recapture" some of those benefits through assessments or taxes. In theory, the accessibility advantages provided by urban rail transit systems are capitalized into nearby property values, building values, or building rents. A key policy question is whether this capitalization effect is large enough in monetary terms, extensive enough in spatial terms, or permanent enough in temporal terms to make the establishment of a transit benefit assessment district (or, alternatively, the collection of a "recapture tax") worthwhile.

2. *Transit-Oriented Development*: The idea that transportation investments are capitalized into land values is hardly a new one. Nor is the idea that transportation investments shape subsequent urban development patterns. Renewed interest in the relationships between transportation investments and urban development patterns has paralleled interest in the so-called "new urbanism." Unhappy with auto-dependent, low-density suburban development forms, the new urbanists argue that many newer communities should be build around mass-transit lines. To the extent that transit-oriented developments substitute for lower-density, auto-dependent development forms, they should, it is argued, also contribute

to lower regional congestion and air pollution levels, as well as to an improved quality of community life. Rail transit investments have been advocated as tools for shaping growth in such West Coast cities as Seattle, Portland, Sacramento, San Jose, San Diego, Oakland, and greater Los Angeles.

Summary of Findings

The fundamental question underlying this research is whether urban rail transit investments affect nearby property values and land uses. The answer to this question, at least for transit systems in California, is *yes*, but not consistently, not by very much, and not always in the ways people expect. Among the specific findings of this report:

1. *Home Prices (Chapter Three)*: Proximity to rail mass transit *is* capitalized into home prices. Among 1990 Alameda County home sales, the price premium for single-family homes associated with (street) distance to the nearest BART station was $2.39 per meter. The 1990 home sales price premium associated with distance to the nearest BART station in Contra Costa County was $1.96 per meter.

This capitalization effect is not universal, however. It depends on many things, quality of service first and foremost. Regional systems like BART, which provide reliable, frequent, and speedy service, and which serve large market areas, are more likely to generate significant capitalization effects. Among California urban rail transit systems, the San Diego Trolley also falls in this category. By contrast, systems which provide limited service, serve a limited market, operate at slower speeds, or do not help reduce freeway congestion are unlikely to generate significant capitalization benefits. CalTrain and light-rail systems in San Jose and Sacramento fall into this category.

2. *Commercial Property Values (Chapter Four)*: Accessibility to rail transit *is not* consistently capitalized into commercial property values. Measured just on the basis of price per square foot of lot area, retail, office, and industrial properties in Alameda County near BART stations did sell at a price premium between 1988 and 1994. Measured in constant quality terms, however — to control for differences in lot and building size — Alameda, Contra Costa, and San Diego office, retail, and industrial properties did not sell at a premium between 1988 and 1994 compared to more distant but otherwise similar buildings.

3. *Station Area Land Use Change (Chapter Five)*: Although there has been a significant amount of land use change near BART stations since the system was first constructed, station proximity by itself does not seem to have a large effect on nearby land use patterns. Various statistical models were developed to separate the effect of station proximity from other factors that affect station area residential and/or commercial land use changes. The models were tested using data on land use changes at nine representative BART stations. In none of the models tested — those involving all land use changes, those limited just to the development of vacant sites, or those involving specific types of vacant land changes — was proximity to a BART station found to be a significant determinant of land use change.

The same result held true for land use changes at four (representative) San Diego Trolley stations between 1980 and 1994: proximity to a Trolley station was not found to be a significant determinant of vacant or developed land use change.

4. *Metropolitan-Scale Land Use Change (Chapter Six)*: A more mixed result emerges if one looks at land use changes at the county or metropolitan scale. The closer a vacant site in Alameda County was to a BART station, the more likely it was to be developed in commercial or industrial use between 1985 and 1990. The opposite was true in Contra Costa County, where, all else being equal, vacant sites near BART station were less likely to be developed into commercial or industrial uses between 1985 and 1990. In both counties, vacant sites near BART stations were less likely to be developed to residential use — in the case of Contra Costa County, far less likely.

Proximity to a BART station does appear to have a positive influence on redevelopment activity, however. All else being equal, residential sites *near BART stations* were far more likely to be redeveloped to commercial or industrial uses than more distance residential sites.

Beyond the Conventional Wisdom

Taken together, these results seem to contradict what has become today's conventional wisdom regarding the relationships between transit facilities, property values, and land use patterns. The conventional wisdom is that commercial properties more than residential properties benefit from proximity to rapid transit stations with respect to sale prices and property values. This report suggests the opposite is true: that the accessibility advantages associated with proximity to a transit station tend to be capitalized into residential property values, but not necessarily into commercial ones.

A second aspect of today's conventional wisdom is that transit investments can encourage beneficial land use changes at or near stations. Beneficial in this context is usually taken to mean greater development activity (thereby reducing development pressures in less transit-accessible locations), or greater densities (thereby substituting pedestrian and transit travel for auto travel). This report, although based on land use changes at a relatively small number of stations, suggests that transit investments have very little impact on nearby land use patterns.

We offer three possible explanations for these contradictions. The first is a critique of the models and data used; the second two explanations address issues of policy.

1. *The Wrong Models, Mis-Used, and Based on Incomplete Data*: One might argue, first, that the various statistical models from which these results are drawn are incomplete, incorporate poor measurements, or are otherwise wrongly specified. This argument may have some applicability to the models of commercial property values presented in Chapter Four; those models are incomplete. With respect to the residential value and land use change results presented in Chapters Three, Five, and Six, the model results are widely consistent with the results of other, somewhat less rigorous approaches.

Second, one might argue that these results are based on limited samples. The residential property value analysis presented in Chapter Three, for example, is limited to residential sales for a single year — 1990. Conceivably, a multi-year analysis might produce different results. The commercial property value data presented in Chapter Four does cover multiple years, but excludes commercial properties in San Francisco. Including downtown San Francisco properties, one could argue, might produce very different results. The station area land use change analysis presented in Chapter Five was limited to nine BART and four San Diego Trolley stations. Although we strove to make the 13 stations representative of their broader systems, one could argue that they are not, and that the results would have been different had one looked at all stations.

2. *An Absence of Supportive Land Use Policies:* A second explanation is more compelling. It is that the land use and commercial property value impacts of BART and the San Diego Trolley would have been greater (than what was observed) if the development of those systems had been accompanied by supportive land use and development policies. The assumption behind this explanation is that transit investments alone, in the absence of other supportive investments and public policies, are insufficient to significantly affect land use patterns and values.

While this explanation may ring true, it begs the larger question of what exactly constitutes *supportive* land use policies. Transit-supportive land use policies are like a two-sided equation. One side of the equation includes incentive policies designed to promote certain types of development near transit stations. Incentive policies may include higher-use or higher-density zoning, other specific public infrastructure investments, certain types of regulatory relief, joint development initiatives, a higher level of urban design quality, and perhaps even subsidies to particular uses. With the exception of two or three stations, the development of BART occurred in the near total absence of locally supportive land use policies. Indeed, at a number of BART station areas, the explicit local response to BART was to prevent the development of different uses or higher densities. The construction of the San Diego Trolley system, likewise, was not accompanied by any significant local land use policy changes — except in downtown San Diego.

The other side of the supportive land use policy equation involves trying to prevent appropriate uses which would otherwise locate near transit stations from "leaking out" to other areas. Practically speaking, this usually involves "down-zoning" suburban locations. A few cities have tried this with partial success. San Francisco's Downtown Plan, for example, has successfully prevented commercial and office uses from encroaching on residential neighborhoods; it has been less successful at focusing such development into the areas adjacent to transit stations. Other cities such as Oakland and El Cerrito have tried to restrict the development of higher-density housing to transit corridors. The essential problem with these types of policies is that they require a tremendous (and heretofore unattainable) amount of inter-jurisdictional coordination. In the absence of such coordination, California cities have fallen into the practice of competing with each other for property-tax-generating commercial developments.

Related to this is the fact that transit rights-of-way and stations are often located in areas which are not particularly amenable to development or redevelopment. San Diego's North-South Trolley line, for example, is wedged between a freeway, naval facilities, and active industrial areas. Most of the development which has occurred in San Diego over the last 15 years has occurred in an entirely different area. BART suffers from a similar problem over much of its right-of-way. Large portions of the Richmond-Fremont line, for example, run through older industrial areas where redevelopment is neither likely nor immediately feasible.

3. *The Weakening Transit-Land Use Connection*: A final explanation is that transit investments may no longer have the ability to substantially impact urban land use forms or land prices. This is the explanation that is most consistent with the findings of this research. It is also an explanation that many transit advocates find difficult to accept. They point to studies documenting the crucial role of rail transit investments guiding the early 20th century development of Boston, Chicago, Oakland, and even Los Angeles. Why, they ask, should rail transit have served to organize urban development patterns 70 or 80 years ago, but not have that function now?

The answer to this question is two-fold. First, a far smaller percentage of today's urban residents rely on transit than was the case even 40 years ago. With most residents preferring to travels via private auto — and with the private auto being a superior mode for most non-work trips — the attraction of living or working near transit (except as a means for coping with street congestion) has steadily declined. Second, what is sometimes forgotten about the electric trolley systems of the early 20th century is that they were privately developed for the express purpose of bringing potential suburbanites to new subdivisions. They were not built for the purpose of guiding redevelopment efforts or promoting infill development. Nor were they planned and constructed by the public sector. The process of land acquisition, subdivision, site planning, and extending transit lines occurred simultaneously and usually under the auspices of a single business entity — the private land developer. Instead of local development policies being shaped to serve transit (as is now being suggested), transit extensions were planned in order to facilitate speculative development.

CHAPTER ONE:
Introduction

1.1. Introduction

Transportation systems are the glue that binds together American cities. From the first boulevard, through the horse-drawn streetcars of the 19th Century, through the electric trolleys of the early 1900s, to the freeways of the post-World War II era, transportation investments have long played a defining role in guiding the growth and development of metropolitan areas. What is today called the "transportation/land-use connection" has been the object of study by geographers and economists for more than 150 years, and the focus of attention for developers and speculators for even longer.

Geographers organize the spatial development of U.S. metropolitan areas into four eras, each of which has been dominated by a particular transportation technology: (i) The Walking-Horsecar era: 1800-1890; (ii) The Electric Streetcar era: 1890-1920; (iii) The Recreational Automobile Era: 1920-1945; and (iv) The Freeway Era: 1945-onward (Adams, 1970). This *evolutionary view* suggests that the role of rail transit investments in shaping metropolitan growth is largely past. Moreover, as Giuliano points out, today's multi-modal urban transportation systems are so well-developed and ubiquitous that even very large investments should have only incremental effects (Giuliano, 1995). Recent empirical studies tend to confirm these views. Studies of the BART system undertaken in the mid-1970s, as well as more recent studies of Portland's light-rail system, suggest that the effects of transit investments on land-use patterns and land values tend to be small and highly localized; and that in the few instances where effects are evident, they are usually limited to immediate station areas.

Despite a paucity of empirical evidence indicating transit's ability to shape urban growth patterns, transit advocates and some urban planners continue to argue for additional transit investments as a way of encouraging more compact, less auto-dependent land-use patterns. Multi-billion-dollar rail transit construction programs have been undertaken in Portland and Los Angeles, based in part on speculative arguments that such investments will succeed in generating higher density (and thus presumably more environmentally sensitive) development forms. The intuitive appeal of this argument notwithstanding, the specific ability of new mass transit investments to alter urban development patterns — whether locally or regionally — remains very much unknown.

This report explores the transit/land-use connection from the transit side. Drawing on data for five urban rail transit systems here in California (BART, CalTrain, Sacramento Light Rail, the San Diego Trolley, and Santa Clara Light Rail), it uses statistical models to clarify the relationships between transit investments, land uses, and property values. Four types of transit/land-use/property value relationships are considered:

- Relationships between rail transit investments and *single-family home prices* (Chapter 3);
- Relationships between rail transit investments and *commercial property values* (Chapter 4);
- Relationships between rail transit investments and *station area* land-use changes (Chapter 5); and,
- Relationships between rail transit investments and *metropolitan-scale* land-use changes (Chapter 6).

Much of this report is focused on two transit systems, BART and the San Diego Trolley system. By just about any measure of system performance — ridership, market capture, fare recovery, vehicle speed, and service quality — these two systems stand head and shoulders above California's other four intra-metropolitan rail transit systems. If rail transit investments do indeed affect land values and land uses, then such effects are likely to be most apparent around BART and San Diego Trolley stations.

1.2. The Policy Context

This report responds to two fundamental policy questions: the first is fiscal in nature; the second relates to issues of development policy.

Policy Question One: Finding New Sources of Transit Operating Funds:

Urban rail transit systems across the country are facing significant fiscal stresses. Capital and operating costs are increasing even as ridership continues to decrease (Lave, 1994; Pickrell, 1985; Wachs, 1989). Transit operating assistance is likely to be significantly reduced or perhaps even eliminated by a Congress hostile to government subsidies in general, and to urban transit subsidies in particular. As operating shortfalls rise, transit operators will increasingly be forced to turn to their ridership base (in the form of higher fares) or to friendly state and local governments for operating assistance. Yet in many states — and certainly in California — state and local governments are facing their own financial shortfalls. If additional operating funds are to be found, they will have to come from new sources.

Benefit assessment districts provide one possible alternative. To the extent that the benefits associated with rail transit systems (and their use) accrue to a broader section of the population than just transit-riders (who presumably pay for the benefits they receive through fares), it may be possible to "recapture" some of those benefits through assessments or taxes. In theory, the accessibility advantages provided by urban rail transit systems are capitalized into nearby property values, building values, or building rents. The extra income which accrues to the owners of such properties is an unearned windfall, generated by the presence of a nearby transit system. The fundamental policy question is whether this capitalization effect is large enough in monetary terms, extensive enough in spatial terms, or permanent enough in temporal terms, to make the establishment of a transit benefit assessment district (or, alternatively, the collection of a "recapture tax") worthwhile. Chapters Three and Four consider the size and extent of transit service capitalization into home and commercial real estate values in various California counties.

Policy Question Two: Transit and Urban Form:

The idea that transportation investments are capitalized into land values is hardly a new one. Nor is the idea that transportation investments shape subsequent urban development patterns. Renewed interest in the relationships between transportation investments and urban development patterns has paralleled (and to a certain extent, been fed by) interest in the so-called "new urbanism." Unhappy with auto-dependent, low-density suburban development forms, the new urbanists argue that many newer communities should be build around mass-transit lines. The "transit village" concept takes this idea one step further: particularly when accompanied by supportive land-use policies, new transit investments can help promote the commercial and residential redevelopment of older urban cores (Cervero, 1993; 1994). And to the extent that transit-oriented developments substitute for lower-density, auto-dependent development forms, they should, it is argued, also contribute to lower regional congestion and air pollution levels, as well as to an improved quality of community life. Rail transit investments have been advocated as tools for shaping growth in such West Coast cities as Seattle, Portland, Sacramento, San Jose, San Diego, Oakland, and greater Los Angeles.

To what extent — if at all — do transit investments really shape future development patterns? The popularity of transit-oriented development and the new urbanism notwithstanding, this question has been the subject of virtually no recent empirical study. If investments in new transit systems or in line expansions are to be undertaken with an eye toward guiding growth, then the question of transit's true capabilities in this regard needs to be addressed. Chapter Five addresses this issue at the station-area scale (that is, within a one-mile radius of specific transit stations); Chapter Six addresses it at the metropolitan scale.

1.3. California's Five Rail Mass Transit Systems: An Overview

Common sense suggests that the effects of transit investments on land values and land uses should vary with distance: the impacts should be larger for close-by properties, and smaller for more distant ones. Another factor likely to be important is transit service quality. All else being equal — including distance and proximity — the effect of transit investments on property values and land uses should be greater for transit systems with higher quality service than for systems with lower-quality service.

The quality of service provided by California's five rail rapid transit systems varies considerably. Much of the variation is reflective of each system's basic design (Table 1.1). BART, the Bay Area Rapid Transit system, is a modern, grade-separated, heavy-rail, high-speed regional rail transit system with frequent service. CalTrain is a state-operated commuter railroad serving San Francisco workers who live on the San Mateo Peninsula. Although not grade-separated, CalTrain does have its own right-of-way. Opened in 1986, the San Diego Trolley serves downtown San Diego from the south and east. Except in the downtown areas, the trolley operates in its own right-of-way. Sacramento's light-rail system, also completed in 1986, is much like San Diego's in configuration. It links several residential areas of the

Table 1.1: System Comparisons between BART, Caltrain, the San Diego Trolley, Sacramento Light Rail, and San Jose Light Rail

Transit System	Year Opened	System Length (in miles)	Number of Stations	Stations with Parking Facilities: # of Stations	Stations with Parking Facilities: Spaces
BART	1972/75	142.0	34	24	31,062
Caltrain	1980	93.8	26	19	3,438
San Diego Trolley	1986/1989	41.0	22	16	
Sacramento Light Rail	1986	36.1	28	9	3,387
San Jose Light Rail	1988	39.0	33	13	6,298

Source: American Public Transit Association and individual operators.

city to downtown Sacramento on a combination of common and separated rights-of-way. Opened in 1988, San Jose's light-rail system is concentrated in the city's downtown area, and although extensions are planned, it does not yet extend to many residential areas. All three light-rail systems are of similar length.

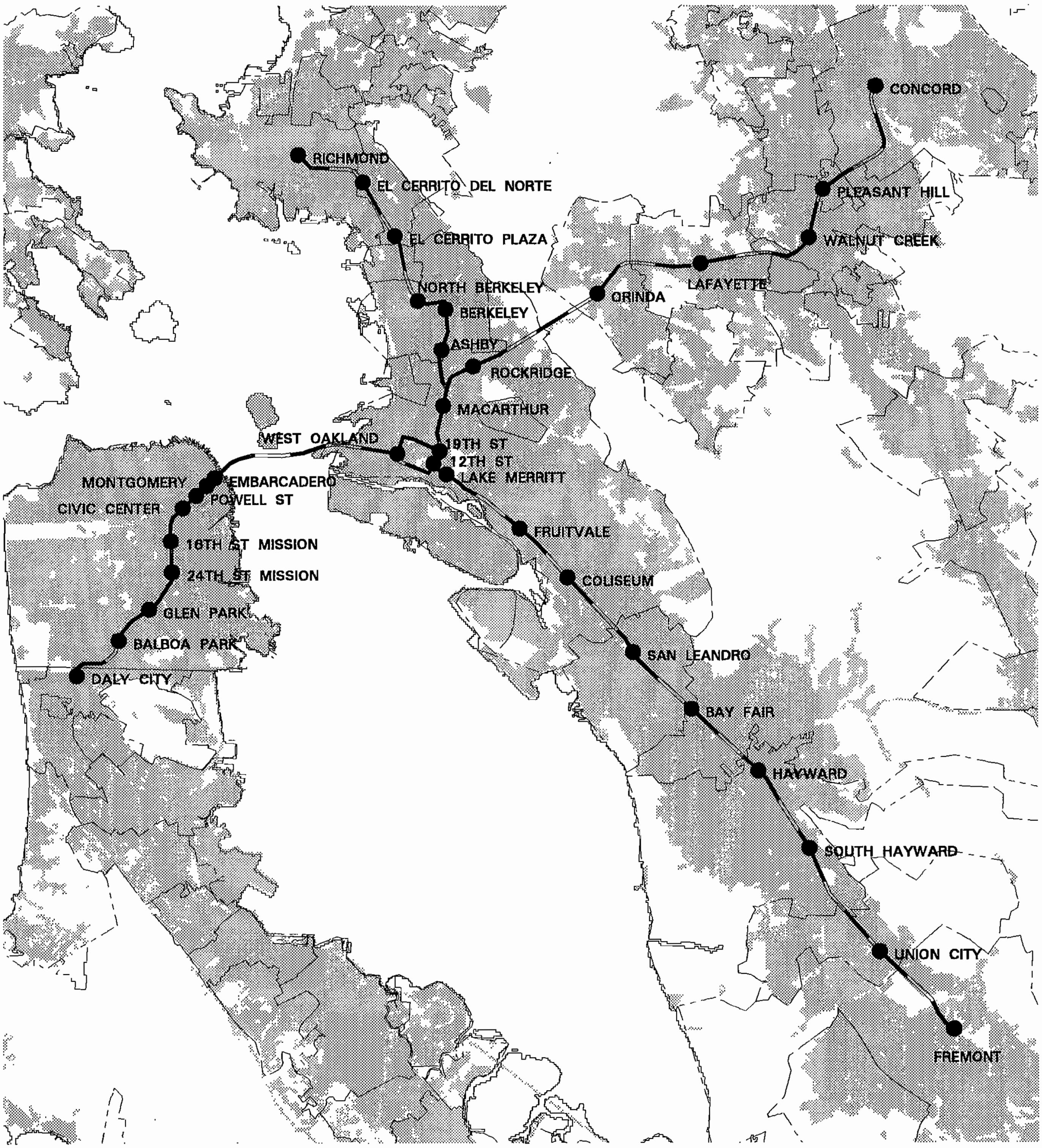
In terms of service quality, BART offers the fastest trains and the most frequent service (Table 1.2). CalTrain offers frequent, speedy service during commute hours, but not during off-peak periods. Two of the three light-rail systems — Sacramento and San Diego — offer comparable levels of service: vehicles on both systems travel at an average speed of about 20 miles per hour, at 15-minute headways during commute hours. Non-peak headways for both systems are roughly 30 minutes. San Jose's light-rail vehicles are slower than San Diego's or Sacramento's but service is more frequent, especially during commute hours. Because all three of the light-rail systems use downtown city streets, service quality and headways may vary according to auto congestion levels.

Table 1.2: Level-of-Service Comparisons between BART, Caltrain, the San Diego Sacramento Light Rail, and San Jose Light Rail

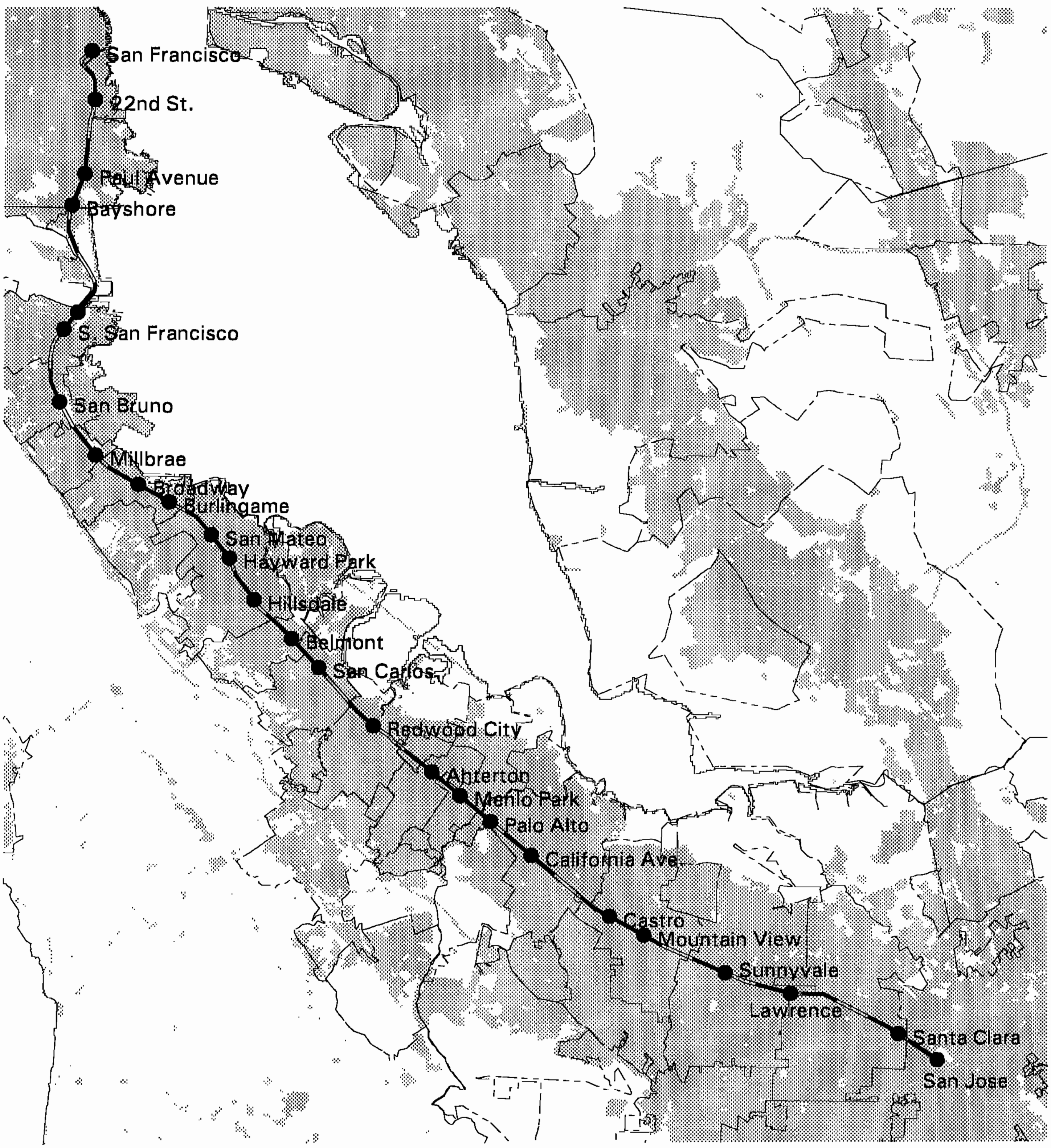
Transit System	Hours of Service	Frequency of Service (min): Peak	Frequency of Service (min): Off-Peak	Avg. Vehicle Speed (mph)	Avg. Fare*
BART	4 am-12 am	3	20	32.1	$1.27
Caltrain	4:50 am-0 pm	4-30	60-120	32.1	$1.66
San Diego Trolley	4:45 am-1:15 am	7	15-30	19.3	$1.20
Sacramento Light Rail	4:30 am-2:30 am	15	30	19.9	$1.25
San Jose Light Rail	5:25 am-2:30 am	10	30	12.8	$1.00

Notes: * For BART & Caltrain this was calculated as: Annual Revenue from Fares/ Annual Unlinked Trips; for light rail systems, these were the actual fares or the average of the minimum and maximum fares.
Source: American Public Transit Association and individual operators.

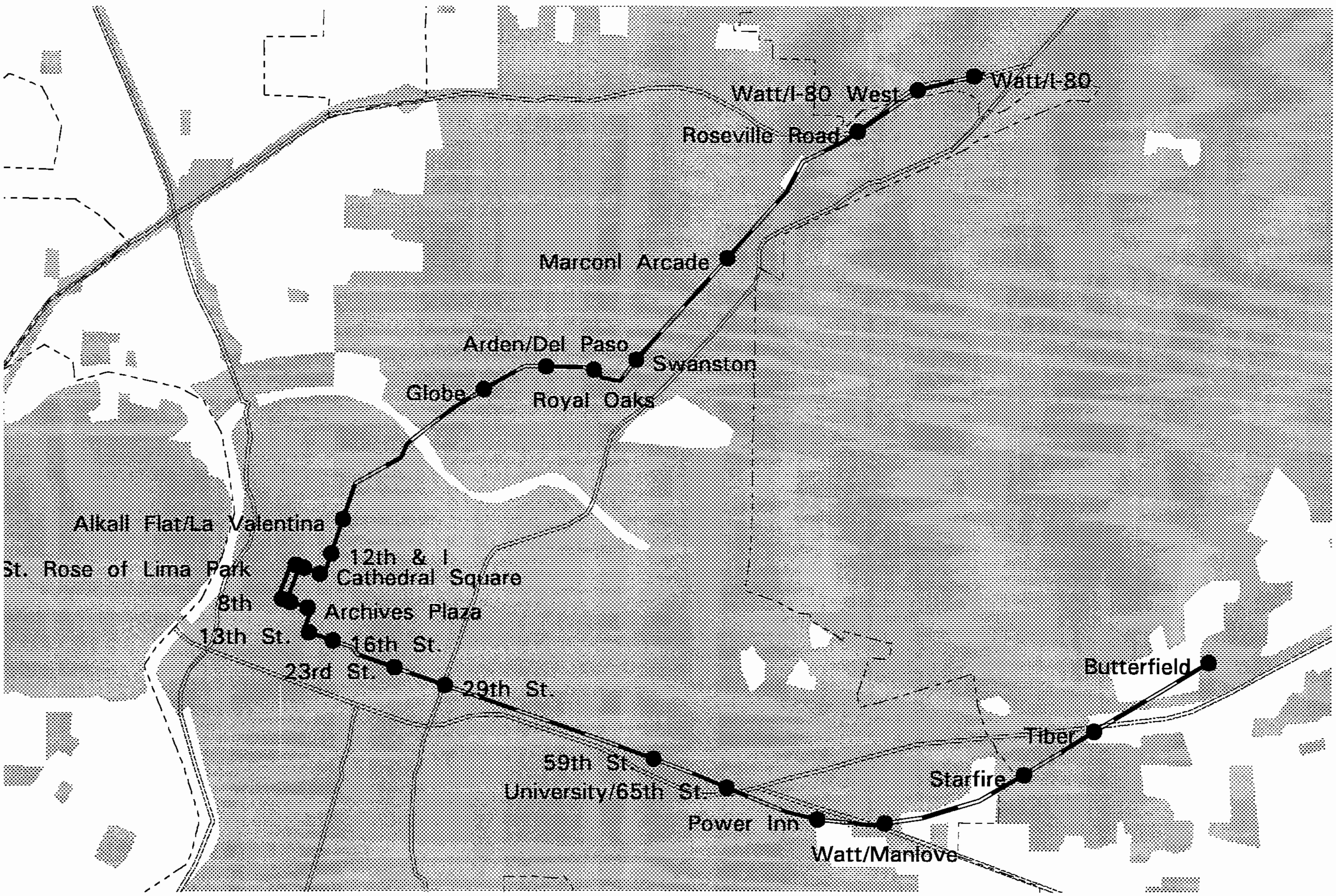
Map 1.1: BART


CONCORD
RICHMOND
EL CERRITO DEL NORTE
PLEASANT HILL
EL CERRITO PLAZA
WALNUT CREEK
LAFAYETTE
NORTH BERKELEY
ORINDA
BERKELEY
ASHBY
ROCKRIDGE
MACARTHUR
WEST OAKLAND
19TH ST
12TH ST
MONTGOMERY
EMBARCADERO
LAKE MERRITT
POWELL ST
CIVIC CENTER
FRUITVALE
16TH ST MISSION
24TH ST MISSION
COLISEUM
GLEN PARK
BALBOA PARK
SAN LEANDRO
DALY CITY
BAY FAIR
HAYWARD
SOUTH HAYWARD
UNION CITY
FREMONT

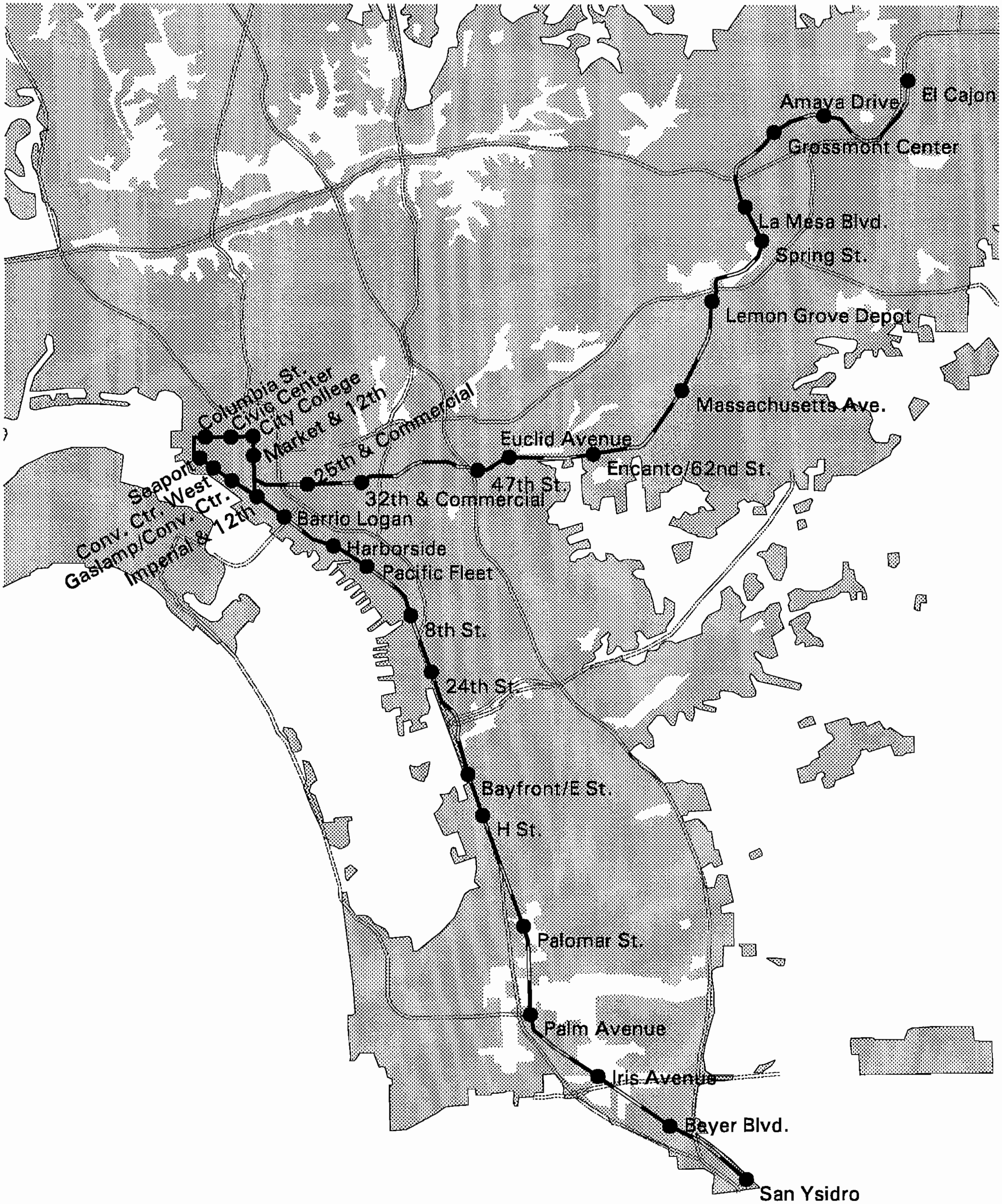
Map 1.2: CalTrain



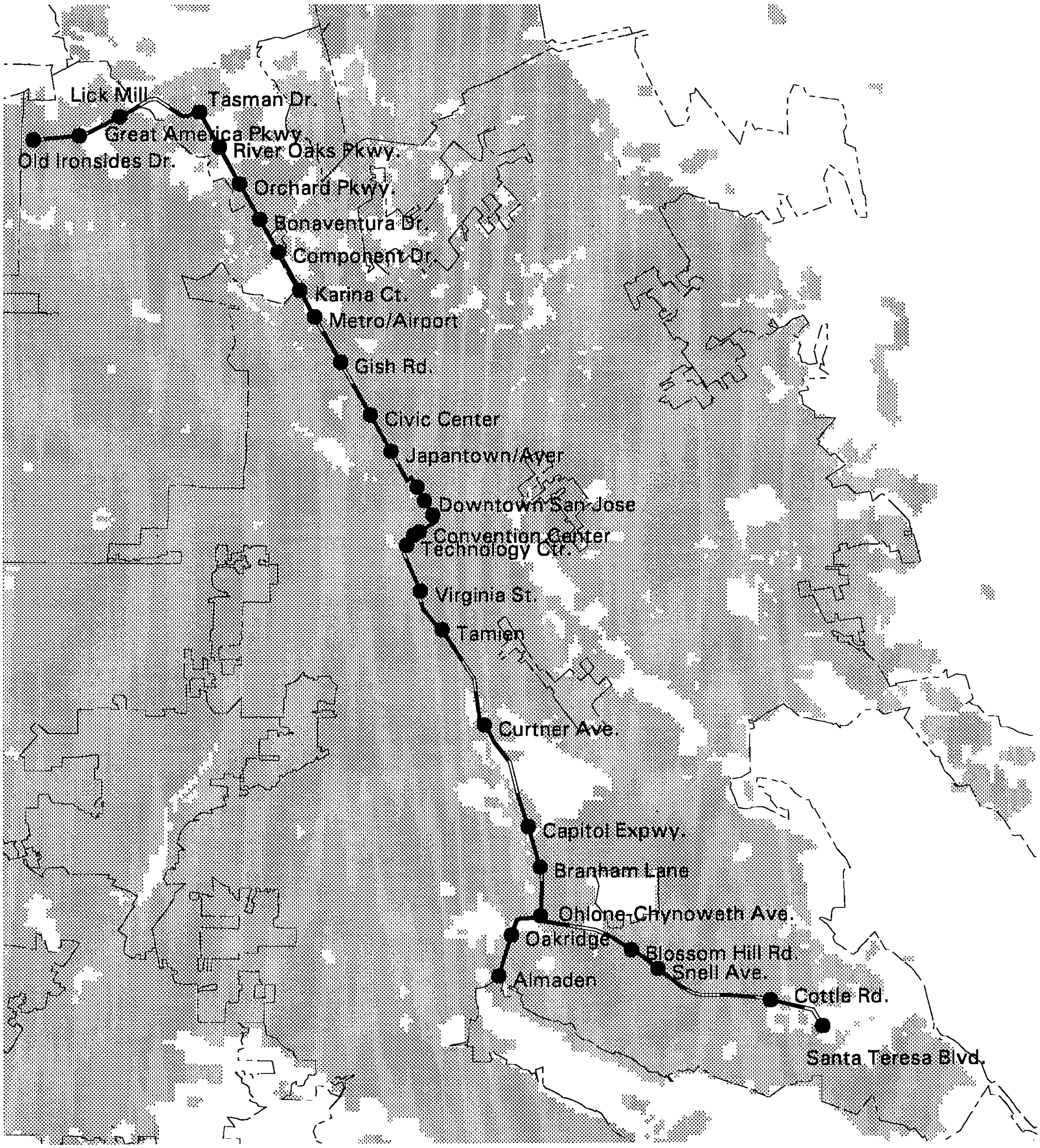
Map 1.3: Sacramento Light Rail



Map 1.4: San Diego Trolley



Map 1.5: Santa Clara Light Rail



Three of the five systems — BART, CalTrain, and San Diego — use a distance-dependent fare structure. Sacramento Light Rail and San Jose Light Rail have a flat fare structure. Per-trip average fares for BART and CalTrain were calculated by dividing total 1991 revenue from fares by total unlinked trips. Average fares for the three light-rail systems were calculated as the average of the minimum and maximum fares. At $1.66 per trip, the average CalTrain trip is considerably more expensive than the average BART, San Jose, Sacramento, or San Diego light-rail trip. With an average fare of $1.00, San Jose Light Rail offers the least expensive service. Average per trip fares on BART, the San Diego Trolley, and Sacramento Light Rail are comparable.

Patronage levels also vary sharply across the five systems (Table 1.3). BART, with 74.7 million riders and 892 million passengers miles in 1991, significantly outperformed CalTrain (5.4 million passengers and 123 million passenger miles) and the three light-rail systems. Among the light-rail systems, the San Diego Trolley carried significantly more passengers (for greater distances on average) than either the Sacramento or San Jose transit systems. Of the five systems, the San Jose light-rail system attracted the fewest passengers in 1991 (2.4 million) and recorded the fewest passenger miles of travel (7.5 million).

Table 1.3: Ridership, Market Area, and Market Capture Comparisons between BART, Caltrain, the San Diego Trolley, Sacramento Light Rail, and San Jose

	1991 Ridership		Avg. Trip	Population of	Market Capture
Transit System	Passengers	Passenger-Miles	Length (miles)	Market Area*	Index**
BART	74,761,736	891,228,943	11.9	2,102,767	35.6
Caltrain	5,437,393	123,483,189	22.7	750,543	7.2
San Diego Trolley	15,933,546	115,518,215	7.3	1,030,183	15.5
Sacramento Light Rail	5,702,520	30,783,073	5.4	739,058	7.7
San Jose Light Rail	2,432,298	7,526,763	3.1	739,891	3.3

Notes: * Estimate of 1990 population within 5 miles of terminal stations and 3 miles of line stations.

** Market capture index is calculated by dividing market area population into 1991 ridership.

Source: American Public Transit Association and individual operators.

Transit ridership depends on many things: service quality and cost, competition from other modes, and the size of the overall market area. To determine the extent of each system's market area, we first assumed a maximum market radius of three miles for each transit station, and five miles for the end-of-the line stations. Next, we utilized a geographic information system to super-impose the various market areas on census tracts to estimate their within-area population totals. Of the five systems, BART has the largest market area (2,102,767 persons as of 1990), followed by the San Diego Trolley (1,030,183 persons). CalTrain, Sacramento Light Rail, and San Jose Light Rail each serve a market area of about 3/4 of a million persons.

Dividing passenger ridership by market size provides a useful index of market capture. For BART, the value of this index in 1991 was 35.6. This is analogous to saying that every person in BART's market area made 35.6 BART trips in 1991. The next highest market capture index was for the San Diego Trolley: 15.5 passenger trips per market area resident. For Sacramento Light Rail, the value of this index in 1991 was 7.7; for CalTrain, it was 7.2. This means that Sacramento Light Rail captured a greater share of its market area than did CalTrain. At 3.3 passenger trips per market area resident, San Jose had the lowest market capture index of the five systems.

The ability of a particular transit station to capture its market area depends in part on how easy it is for potential riders to get to that station. Market capture depends on the extent to which complementary bus service is available, on the convenience of kiss-and-ride facilities, and on parking availability. It is in this last area — parking capacity — that there are significant differences among the five systems. Systemwide, BART can accommodate more than 31,000 daily parkers at 27 stations (seven stations do not have parking facilities). Nineteen of 26 CalTrain stations have some parking facilities; however, their collective capacity — at 3,438 spaces — is much lower than that of BART. The three light-rail systems offer parking at their outlying stations. Systemwide, the San Diego Trolley can accommodate 4,533 daily parkers at 16 stations. Thirteen San Jose Light Rails stations offer 6,298 parking spaces. The Sacramento light-rail system is the most parking constrained of the five systems: parking is available at only nine of the system's 28 stations. BART's ability to park so many more cars at more of its lots than the other four system make it much more accessible to its service area.

1.4. Report Organization

The rest of this report is organized into six chapters. Chapter Two summarizes the general theory linking transit investments, land uses, and property values. It also reviews a wide variety of empirical studies. Chapter Three examines the extent to which BART, CalTrain, and light-rail service in San Diego, San Jose, and Sacramento is capitalized into single-family home prices. Chapter Four presents an analysis of the capitalization of BART and San Diego Trolley service into nearby commercial property values. Chapter Five explores the determinants of land-use changes at nine BART stations between 1965 and 1990, and at four San Diego Trolley stations between 1980 and 1994. Chapter Six extends the methodology developed in the previous chapter to consider the impacts of BART service on metropolitan-scale land-use changes between 1985 and 1990. Chapter Seven summarizes all of the research findings and discusses their implications.

CHAPTER TWO:
Theoretical Foundations and Literature Review

by John D. Landis and William Huang

Economists and geographers have been writing of the connections between transportation investments, urban development forms, and property values for nearly 150 years. Indeed, the relationship between transportation costs and urban activity patterns defines contemporary urban economics. Recent summaries of the transportation/land-use/land price literature can be found in Muller (1986), Giuliano (1986), Handy, (1992) and Kelly (1994).

2.1. The Economics of Land Uses, Land Prices, and Urban Form

Urban economists view urban land prices and use patterns as the joint outcome of competition between households for residential locations, and commerce and industry for business locations (Alonso, 1964; Muth, 1969; see Mills and Hamilton; 1989, for a concise presentation of the general theory). In choosing how far from the metropolitan Central Business District (CBD) to live, utility-maximizing households are assumed to trade off marginal decreases in housing costs (composed of both structure and land) against marginal increases in CBD-oriented transportation costs. The chosen residential location of any given household will thus depend on its relative preferences between housing and transportation. Profit-maximizing business are similarly assumed to choose those locations by balancing their specific land area requirements against the total costs of transporting inputs from suppliers (sometimes including labor), and outputs to markets.

Land markets serve as auction places between different households and business. Whichever household or business is willing to bid the most for a given location (according to their incomes, profits, housing-transportation preferences, or land area transportation preferences) is presumed to win, and the overall pattern of urban land uses emerges as a composite or envelope of winning bids. To the extent that businesses and industries are more sensitive to transportation costs than households, they are presumed to place a higher value on downtown locations than households. Similarly, to the extent that wealthier households place a higher value on land or space than lower-income households, they will win the bidding for lower-density suburban locations. Although extraordinarily simplistic, this model has a number of attractive features. It nicely explains why different uses tend to cluster at different distances from the CBD. It also explains patterns of land prices — which are simply bid prices for location. Perhaps most importantly, it reasonably explains (or at least did explain, until recently) the basic pattern of land uses in American metropolitan areas.

Transportation Investments and Urban Form

The model also provides a consistent framework within which to evaluate the land-use and land price effects of transportation investments. Transportation investments which result in reduced work-place commuting costs will facilitate households' moving outward from traditional workplace centers. Suburban and exurban densities and land prices will rise, as central densities and land prices fall. (This change is usually referred to as a "flattening" of the bid-rent curve.) Retail and population-serving businesses will follow their customers to the suburbs, as, in the long run, will regional and international businesses, depending on their relative price elasticities of labor (Mills 1972: 127; Alcaly 1976).

Corridor-oriented transportation investments, such as freeways or rail transit lines, will generate two types of effects. Locations within or near a particular corridor will increasingly come to serve as substitutes for downtown locations, and densities and land prices within the corridor will rise. At the same time, accessibility to the urban fringe via the corridor will be enhanced, causing the urban area to extend outward along the corridor.

Transportation investments which relieve congestion will have two effects. By making core areas relatively more accessible, they will contribute to increased densities and land prices in urban or suburban centers — at least in the short run. In the long run these same investments may make it easier to travel to less congested areas, leading to decentralization. Finally, to the extent that transportation investments improve accessibility *everywhere within a region* — thus making travel generally easier or less expensive — they will tend to result in reduced densities and a more homogeneous distribution of urban activities throughout the metropolitan area.

Mode also matters. Investments in fixed-route transit modes will tend to have a lesser effect on regional land-use patterns and prices, but (depending on the level of service) a potentially greater effect on corridor land uses and prices. Investments in freeways and surface streets, by contrast, will tend to result in a more diffused pattern of land use and price changes.

All else being equal, investments in private transportation modes (such as freeways) will tend to result in residential patterns that are more segregated along income lines, since wealthier households may be able to purchase additional levels of service. Investments in public transportation modes will tend to be more neutral with respect to income and residential segregation.

Ironically, transportation investments which lower the cost of travel will tend over the very long run to reduce transportation's influence on urban form and urban land prices. As neo-classical economics suggests, any drop in the price of a good will trigger two effects: (i) an income effect, leading to greater consumption of the now-less expensive good; and (ii) a substitution effect, encouraging consumers to substitute away from similar-but-more expensive goods. For some households, the income effect may dominate, leading them to move ever further out. For other households the substitution effect may be more important, enabling them to choose their residential locations according to other concerns, including education quality and cost, local public service quality and cost, and the availability of public and private amenities.

The Capitalization Dynamic

The mechanism by which transportation investments and changes in accessibility are converted into land value changes is known as *capitalization*. All else being equal, one would expect investments in fixed-route transportation systems (such as rail transit) to produce more intense, but less extensive, capitalization effects than investments in flexible route transportation systems such as roads. This is because the supply of developable sites near fixed-route systems is necessarily more limited than the supply of sites near flexible-route systems, particularly if access to the fixed-route system is limited to a small number of stations.

The capitalization effect both causes, and is a product of, higher densities and/or more intense land uses. On the cause side, as land prices rise (that is, as transportation investments are capitalized into land prices), investors in land will want to receive the same marginal return on their investments. Either they will have to charge their tenants a higher rent (or subsequent buyers a higher price), or increase the amount of income from a given land area. The former response is not always feasible; the latter response takes the form of higher densities. This dynamic works the other way as well. Higher density developments produce higher rents and income streams for their owners. The higher income streams are then capitalized into higher resale prices, and ultimately higher land prices.

2.2. Transportation Technologies and Metropolitan Form

Geographers have always been more interested in the ways that changing transportation *technologies* have transformed urban spaces, than on the impacts of particular transportation investments. Following Adams (1970), Mueller (1986) organizes the spatial evolution of first cities, and then later metropolitan areas into four distinct eras, each of which is dominated by a particular transportation technology:

1. The walking-horsecar era (1800-1890)
2. The electric streetcar era (1890-1920)
3. The recreational automobile era (1920-1945)
4. The freeway era (1945 onward)

The size of the American city in 1800 was determined by how far one could walk in an hour or less. Despite being relatively small in extent, cities were hardly homogeneous. As Schaeffer and Sclar (1975) point out, the pre-industrial walkable city included recognizable business and industrial districts, as well as the beginnings of income-based residential communities. Prior to 1830, commuting was a seasonal rather than daily activity. During the summer months, wealthy businessmen would commute from their downtown jobs to their country homes on Fridays, and from their homes to their jobs the following Monday. The development of suburban railroads in the early 1830s turned the commute into a daily event, and by the 1840s, hundreds of affluent businessmen in New York, Boston, and Philadelphia were commuting on a daily basis. Gradually, the privilege of commuting was extended to the professional classes.

As industrialization accelerated during the 1840s and 1850s, the physical and social environment of American cities worsened notithceably. Unable to afford the cost and time of commuting, and with the pedestrian city stretched to its limits, pressures mounted to improve transport technologies. The modest improvement in mobility afforded by the introduction of the horse-drawn streetcar in 1852 opened previously undeveloped suburban lands for new home construction, and middle-income urbanites flocked to these *horsecar suburbs*.

The era of the horsecar suburb lasted less than forty years. With the invention of the electric traction motor in the 1880s, horsecar suburbs were quickly transformed into streetcar suburbs. The speed with which this transformation took place was unprecedented. The first electric trolley line opened in Richmond, Virginia in 1888. A year later, electric trolleys were in use in 25 cities. By the early 1890s, electric streetcars were the dominant mode of intra-urban transit. On the West Coast, electric streetcar systems were constructed in Los Angeles, San Francisco, Oakland-Berkeley, and San Diego.

The outward expansion of streetcar systems caused the form of urban areas to change, from what had been essentially circles (or some part thereof) into star-shaped entities whose points were residential neighborhoods organized around individual lines. The growth of these new residential neighborhoods was in turn accompanied by an entirely new land-use form, the neighborhood commercial center — usually located at or near a streetcar stop. As the cost of intra-urban travel declined, trip-making behavior became more and more frequent. For nonresidential activities, the growing ease of movement quickly triggered the emergence of specialized land-use districts for commerce, industry , and transportation. By 1920, a ubiquitous network of electric trolleys, trains, interurbans, and finally subways had transformed American cities into metropolitan areas.

The advent of the private automobile further extended urban travel distances and thus the boundaries of metropolitan areas. That the automobile would have such a profound effect on the form and structure of urban areas was not immediately apparent, certainly not when compared with the almost instantaneous transforming effect of streetcars some 30 years earlier. While automobiles were quickly and widely adopted in rural areas, in cities, cars were initially purchased for weekend outings and recreation (Mueller, 1986). It was in the new suburbs that the diffusion of the automobile was most apparent. According to Flink (1975: 14), as early as 1922, more than 135,000 suburban homes in 60 metropolitan areas were entirely auto-dependent. The rapid rise of the private automobile as the suburban commuter's mode of choice had an immediate and devastating effect on streetcar patronage — so much so that by the late 1930s, suburban builders no longer found it necessary to subsidize streetcar companies to provide access to their subdivisions.

The pattern for post-World War II freeways was established in the 1920s, with construction of various landscaped parkways. These motorways extended deep into the suburban and exurban areas surrounding cities, opening up unprecedented amounts of acreage for immediate residential development. As Table 2.1 shows, suburban growth rates began to surpass those of the central cities as early as the 1920s. By the 1930s, suburban growth rates were 150 percent those of central cities. Aided by zoning and suburban-oriented FHA financing, this differential became even more pronounced in the 1950s. The advent of the private auto also accelerated the suburbanization of manufacturing activities (which had been going on since the 1890s) as well as generated an entirely new land-use form — the suburban shopping center.

Table 2.1: Intrametropolitan Growth Trends: 1910-1960

Decade	Central City Growth Rate	Suburban Growth Rate	Share of SMSA Growth in Suburbs
1910-20	27.7%	20.0%	28.4%
1920-30	24.3%	32.3%	40.7%
1930-40	5.6%	14.6%	59.0%
1940-50	14.7%	35.9%	59.3%
1950-60	10.7%	48.5%	76.2%

Source: Mueller, 1986.

As Mueller notes, the postwar Freeway Era was more a continuation and acceleration of previous trends than something entirely new. The private automobile was no longer regarded as a luxury; it had become a necessity for commuting, shopping, and socializing. More and more, suburbanites were undertaking all of their non-work activities in suburbs. Suburb-to-suburb travel began replacing suburb-to-city travel as the dominant trip type. Transit, which had been continuously losing market share on the former type of trip, was completely infeasible for the latter type. With the advent of suburban "beltways" in the 1950s and 1960s, the private car's victory over transit was complete. Planners no longer spoke of transit's ability to organize metropolitan activities and land uses; that role now belonged to the car. By 1970 the fundamental *raison d'etre* of urban transit had been changed: its new purpose was to complement freeways by relieving congestion,[1] or to provide essential mobility to the carless.

2.3. Empirical Studies of the Effects of Transportation Investments on Patterns of Land-Use Change

Given the richness of the theoretical and historical literature linking transportation investments and urban form, the empirical literature is surprisingly thin. The few empirical studies that have been done linking transportation investments and land-use changes can be divided into three broad categories. The first includes studies of changes in the total amount of urbanized land at the metropolitan scale —

that is, *the extent of the metropolitan areas*. A second category consists of studies of changes *in metropolitan land-use patterns*. A third category includes studies of the impacts of highway and or transit construction on adjacent or nearby land parcels.

Empirical Studies of Urbanized Land Change

The number of studies in this first category has grown rapidly in recent years, fueled by concerns that pace of suburbanization — and the impact of suburbanization on agricultural and natural resource areas — has been increasing. The main purpose of many of these studies is descriptive: to document the conversion of open space and agricultural land to urban uses. Drawing on a detailed land-use data from "fast growth counties" in the United States,[2] Vesterby and Heimlich (1991) found that there had actually been very little change in marginal rates of urban land consumption between 1960 and the early 1980s.[3] Vesterby and Heimlich did not explicitly consider the effects of transportation or accessibility in their analysis.

A similar study by Alig and Healy (1987) used regression analysis to examine variations in the change in urbanized land area among different U.S. metropolitan areas between 1970 and 1980. Personal income, change in urban area population, and a dummy variable for Southern states were found to be positive and significant predictors of urbanized land area change; accessibility, transportation infrastructure, and land-use controls were not included in the various specifications.

Empirical Models of Metropolitan- and City-Scale Land-Use Change

A second category of empirical studies considers the role of transportation facilities and/or accessibility as they affect patterns of land-use changes at the metropolitan scale or city scale. At the metropolitan scale, Bourne (1969) produced a two-part model of land-use change for metropolitan Toronto. The first part of Bourne's model consists of a regression model of land development and consumption by land-use type (residential, office, parking, apartment, and single-family) for different subareas of Toronto. Key variables in the first part of the model include measures of accessibility to the CBD, to various mass transit stations, and to metropolitan population and employment centers The second part of Bourne's model is a series of probability matrices describing historical land-use changes within subareas. Putting both parts together, Bourne found that distance to the city center and/or adjacency to the Yonge Street Subway were significant predictors of the amount of new residential, apartment, and office development, as well as the construction of parking facilities.

More recently, McMillen used a multinomial logit model to analyze property-by-property patterns of land conversion in McHenry County, Illinois, between 1979 and 1983. McMillen included three explicit transportation facility measures in his analysis (share of quarter-section land in transportation, local street, and railroad uses, respectively) and four implicit measures (distance from downtown Chicago, distance to the closest city of 10,000 or more population, distance to the closest city of 10,000 or less, and a distance variable combining the city-size thresholds). Proximity to a railroad was found to be a strong deterrent to residential development. Parcels located in quarter-sections with large shares of transportation and street land uses were somewhat less likely to be developed into residential use. Parcels nearer Chicago were more likely to be developed in residential use, as were parcels near other large towns or cities. McMillen's work is less notable for its generalizeability (it applies to a single county at the urban fringe, not a full metropolitan area) or its precision (the ways in which adjacent land uses are measured are admittedly rough) than for its use of a logit model to analyze discrete land-use changes.

At the city level, Lee (1979) analyzed land-use change in Urbandale, Iowa, a suburb of Des Moines. Instead of specific properties, Lee's unit-of-analysis consisted of 20-acre grid-cells coded by dominant land use, and assembled from aerial photographs from 1950 through 1974. Lee ran three regression models: (1) a model explaining the urbanization of cells initially in agricultural use; (2) a model explaining the rate of change in urbanized land area, coded by intensity of urban use; and intensity of land use); and (3) a cross-sectional model explaining the distribution of land use at a given point in time. Several measures of accessibility were included as independent variables in each model. Travel time (from the center of each grid cell) to downtown Des Moines was found to be the most significant accessibility variable included in Lee's first model of agricultural land conversion.[4] In Lee's second model, both travel time to downtown Des Moines, and distance to the nearest interstate access road were found to be significant predictors of the rate of urbanization in some or all of the time periods studied. The presence of contiguous development was also found to be a significant determinant of the rate urbanization.

Also at the city level, Wilder (1985) used an analysis-of-variance procedure to study parcel-by-parcel land-use change in Ann Arbor between 1975 and 1982. She considered land-use shifts between eight economic activities, and the relationship of those shifts to: distance from the CBD, lot size, floor area, and structure age. She concluded that (p. 342):

> *Land-use succession* (italics added) among residential activities is most clearly affected by parcel location, floor area, structural age, and acreage characteristics. However, these factors have varying impacts on land-use changes among non-residential parcels. *Land conversion* is affected primarily by distance from the CBD and parcel acreage, although these factors are moderated by the requirements of the land development process. In general, distance from the CBD is the most important variable in both succession and conversion processes.

The Effects of Transportation Investments on Nearby Land Uses

The third and final category of land conversion models includes studies of the effects of transportation investments on *nearby* land-use patterns. This category can be further subdivided into three groups: (1) studies of the effects of infrastructure in general on localized land-use change; (2) studies of the effects of highway investments on localized land-use change; and (3) studies of the effects of transit investments on localized land-use change.

General Infrastructure Studies: A 1975 study of the Boston, Denver, Minneapolis-St. Paul, and Washington, D.C., metropolitan areas by the Environmental Impact Center considered the effects of all types of public infrastructure investments on development patterns. It concluded:

> A basic conclusion of this study, supported by both the literature review and the statistical analysis, is that public infrastructure investments can have an important impact on the location, type and magnitude of development, particularly for single family homes. (p.1)
>
> The available evidence suggests that households and businesses prefer good access by highway, all other factors held constant. In terms of actual location, single-family home construction has a tenuous connection to new highways, multi-family residential and commercial development appear to be influenced by highways, and the relationship of industrial development to highways is unclear (p.8)

This conclusion was echoed a year later, in an influential report by the Council on Environmental Quality entitled *The Growth Shapers:*

> The link between infrastructure investments and land-use changes has long been recognized in a general way, but little has been done to control the design and location of new infrastructure (Urban Systems Research and Engineering, p. 5).

Highway Studies: The empirical literature on the effects highway investments on nearby land uses is too broad and varied to present in a few paragraphs. Among the more notable studies of the past 20 years:

- Corsi (1974) used stepwise linear regression techniques to explain parcel level land-use changes within a 1.5-mile radius of interchanges on the Ohio Turnpike. He considered five types of developed land uses (any urban use, residential development, highway-related commercial uses, other commercial uses, and industrial uses), and concluded that:

  > The development observed at these interchanges can best be explained by the proximity of these interchanges to large and small urban centers, by the growth rates of the nearest large and small urban centers, by the existence of extensive public facilities in the interchange community, and by the amount of traffic on the turnpike and on the roads that intersect the turnpikes (p. 250).

- In a 1980 study of the regional beltways around Atlanta, Baltimore, Columbus, Louisville, Minneapolis-St. Paul, Omaha, Raleigh, and San Antonio, the Payne-Maxie Consultants and Blayney-Dyett found beltway development to be an important but by no means dominant factor contributing to the decentralization of urban activities. Depending on the metropolitan area, other factors (such as the stringency of local land use and annexation controls, and the availability of easily developable land) were also found to be of complementary importance.

Transit Studies: Compared to highways, the land-use impacts of transit investments tend to be much more modest. In a study of Philadelphia's Lindenwold High Speed Line, Gannon and Dear (1972) noted that transit stations sometimes — but only sometimes — served to help focus suburban apartment and office development. The authors concluded that although the line may have been a factor in the locational decision of developers, other factors such as land availability, perceived demand, current zoning, and local political attitudes were more important. These same factors were cited by Knight and Trygg (1977) in their seminal literature review of the land-use impacts of transit investments.

Early studies of the land-use impacts of the BART system — undertaken in 1978, when the system was less than five years old — concluded that the system had thus far had little impact on land uses at the regional or station area level (Dvett, Dornbusch, Fajans, Falcke, Gussman, and Merchant, 1979).

In addition to these evaluative studies, a number of predictive studies of the land-use impacts of proposed transit investments have been undertaken using available land-use transportation models. Most notable is a study by Berechman and Paaswell (1983) in anticipation of construction of the Buffalo light-rail transit system. Berechman and Paaswell used the Garin-Lowry land-use model to project how the system would affect retail activity, downtown accessibility, economic growth, and land development patterns. Various simulation runs suggested that the system would have comparatively little effect on land development patterns and retail activities across the Buffalo region, or at individual stations. What minimal effects the system would produce would be concentrated in downtown Buffalo.

2.4. Transportation Investments and Land and Property Values: The Empirical Record

Perhaps because property value data is more widely available than land-use data, far more empirical studies have been undertaken of the relationships between transportation investments and property values than between transportation investments and land use. By our count, more than two dozen empirical studies of highway and transit capitalization have been undertaken over the past 40 years. These studies can be organized along a number of dimensions (Table 2.2):

1. *By type of facility:* Some studies consider highway or freeway capitalization, others focus on transit.
2. *By type of effect:* Some studies consider only positive capitalization effects — that is the benefits of improved accessibility. Other studies consider negative capitalization — the disamenity costs associated with noise or congestion.
3. *By property type:* Empirical studies of transport capitalization are about evenly split between analyses of undeveloped land values (usually based on appraised or assessed values), and analyses of housing prices (usually based on sale transactions, and limited to single-family homes). Studies of commercial rent or value differentials attributable to transportation accessibility are far fewer in number.[5]
4. *By type of effect:* Most empirical studies of the capitalization of transport facility benefits take one of two approaches: (1) longitudinal studies comparing land value or price changes for sites near or adjacent to a newly constructed facilities,[6] or, (2) "hedonic" studies comparing price variations across multiple properties as a function of distance or proximity to a particular transport facility, holding constant other property attributes.[7] Additionally, a few empirical studies have been based on case studies and/or survey data.

Highway Capitalization Studies

Economists have been conducting empirical studies of the property value effects of highways since the early 1950s. Most measure capitalization in the same way: in terms of increased property

Table 2.2: Summary Comparisons of Selected Highway and Transit Capitalization Studies

Authors	Facility and Study Area	Property Type	Comparison Method	Effect Type (Accessibility or Disamenity)	Accessibility Measure	Result
Highway Studies						
Adkins (1957)	Dallas	Land	Sales prices & Assessed values	Both	Distance rings	Proximity to highway associated with higher property values
Cribbins (1962)	Cumberland, Guilford, & Rowan counties (North Carolina)	Land	Sales prices	Both	Airline distance	No highway effect observed
Buffington (1964)	1. Austin, TX	Unimproved Land	Sales prices	Both	Distance rings	163% premium associated with highway proximity
	2. Temple, TX	Subdivided Land	Sales prices	Both	Distance rings	13% discount associated with highway proximity
Brown & Michael (1973)	Indianapolis	Land	Assessed land value	Both	Distance Rings	Positive accessibility/ Negative disamentity values
Allen (1981)	1. Northern Virginia	Single-family homes	Sales prices	Disamenity	Decibel level	-$94 per decibel
	2. Tidewater, VA	Single-family homes	Sales prices	Disamenity	Decibel level	No effect
Langley (1981)	Washington, D.C.	Single-family homes	Sales prices	Both	Distance rings	$3,000 to $3,500 discount for homes within 1000 feet of highway
Palmquist (1982)	Washington (state)	Single-family homes	Sales prices	Both	Distance rings	Up to 15% appreciation premium from accessibility; up to 7.2% discount based on noise
Tomasik (1987)	Phoenix	Single-family homes	Sales prices	Both, separately	Distance rings	Highway had positive effect, but no gradient observed
Transit Studies						
Davis (1970)	BART/San Francisco	Residential	Sales prices	Both	Airline distance	Concludes BART stations had a positive effect on home values
Lee (1973)	BART/San Francisco	Single-family homes	Sales prices	Both	Airline distance from BART station	Price premium observed in BART service corridor, but no station effect observed
Damm, et.al. (1980)	Metro/Washington, D.C.	Single and multi-family housing, retail	Sales prices	Both, separately	Airline distance from station	Found negative price elasticities with respect to distance from Metro stations
Boyce, et.al. (1972)	Lindenwold Line/ Philadelphia	Single-family homes	Sales prices	Accessibility	Commute cost savings	Positive impact of line on property values
Dornbusch (1975)	BART/San Francisco				Airline distance from station	Reduced property values around some station areas
Dewees (1976)	Bloor St. Subway/Toronto	Low-density housing	Sales prices	Accessibility	Weighted commute time	
Blayney Associates (1978)	BART/San Francisco Bay Area	Residential, commercial		Both	Airline distance from station	Increased property values for properties within 1000 feet of some stations
Baldassare, et.al. (1979)	BART/San Francisco Bay Area	Residential	Resident surveys	Disamenity	Distance rings	Reduced preference for homes near selected BART stations
Bajic (1983)	Spadina Line (Toronto)	Residential	Sales prices	Both	Weighted commute time	$2,237 premium for the average home, based on commute time savings
Picket & Perrett (1984)	Metro/Tyne and Wear Counties (UK)	Residential	District values	Accessibility	Distance rings	L360 appreciation premium for properties near Metro
Allen, et.al. (1986)	Lindenwold Line/Philadelphia	Single-family homes	Sales prices	Accessibility	Commute cost savings	$443 home value premium per dollar of commute cost savings; $4581 average home value premium

Authors	Facility and Study Area	Property Type	Comparison Method	Effect Type (Accessibility or Disamenity)	Accessibility Measure	Result
Ferguson (1988)	Light-Rail/Vancouver	Single-family homes	Sales prices	Both, separately	Airline distance from station	C$4.90 premium per foot associated with station proximity in 1983
Voith (1991)	PATCO Commuter Rail/ Philadelphia SEPTA Commuter Rail/ Philadelphia	Single-family homes Single-family homes	Census tract median home values	Both	Tract adjacency to rail station	10% home price premium for median home in served tracts 3.8% home price premium for median home in served tracts
Alterkawi (1991)	1. Metro/Washington, D.C. 2. MARTA/Atlanta	Land Land	Assessed values Assessed values	Both Both	Airline distance from transit stations	Higher assessed values (Range: $-.01 tp $-.11 per square foot) for sites near stations
Nelson (1992)	MARTA East Line/Atlanta	Single-family homes	Sales prices	Both, separately	Airline distance from station	Magnitude of premium or discount varies with neighborhood income level
Al-Mosaihd, et.al. (1993)	Light Rail/Portland	Single-family homes	Sales prices	Both	Distance rings based on walking	$4,324 premium for homes within 500m walking distance of light rail station
Gatzlaff & Smith (1993)	Metrorail/Miami	Single-family homes	Sales prices	Both	One-mile sec tion for repeat sales; airline distance for hedonic models	No effect

values over time as a function of distance to the highway right-of-way. Virtually all of the early highway studies found large and significant land value increases associated with highway construction. Buffington's and Meuth's 1964 report on Temple, Texas, for example, tracked 19 years of land value changes and concluded that (p. 11): "the probable highway bypass influence in the Temple area was 2,562 percent, or $2,331. This represents a tremendous increase in land value in the study area as opposed to the control area."

More recent studies — especially those that focus on home prices instead of land — have been more ambivalent. Langley (1981), for example, used 17 years of home sales data from North Springfield, Virginia, to evaluate the impacts of the Washington Capital Beltway. He concluded that properties adjacent to the Beltways sold at a discount and appreciated at a reduced rate when compared with more distant properties. Palmquist (1982), in an analysis of single-family home prices in Washington state, and Tomasik (1987), in a study of home prices in Phoenix, both report net positive property value effects associated with highway construction, but also acknowledge that for the closest homes, accessibility premiums may be offset by noise-related price reductions.

Transit Capitalization Studies

Most contemporary studies of transit capitalization utilize hedonic models of residential sales prices (as opposed to assessor or appraiser estimates of value). No single functional form dominates the literature. Many studies use simple linear forms; others model multiplicative or exponential relationships.

Most transit capitalization studies use distance from the nearest transit station (either as measured along streets, or as-the-crow-flies, or in terms of distance rings) as the critical independent variable for modeling the price effects of transit. Studies of the Toronto Subway and Philadelphia-Lindenwold High Speed Line, however, obtained good results using alternative independent variables. Dewees (1976), concluded that a weighted travel-time-based measure was superior to distance-based measures for predicting the rent gradient around Toronto's Bloor Street Subway. Bajic's 1983 study of the Toronto Subway's Spadina Line also relied on travel time instead of distance. Three Lindenwold studies published during the 1970s (Boyce et al. [1972]; Allen et al. [1974], and Mudge et al. [1974]) utilized relative travel cost savings to model the property values effects of the line. More recently, Allen, Chang, Marchetti, and Pokalsky (1986) attempted to calculate the actual commute cost savings associated with the Lindenwold line.

These various studies have produced wildly different estimates of the value of station proximity. Two studies published in 1993 provide a good illustration of this range. At one extreme, Gatzlaff and Smith used repeat sales in a hedonic price model to evaluate the change in home prices attributable to the Miami Metrorail system. They concluded that residential sales prices were, at most, only weakly affected by the announcement of the new rail system. At the other extreme, Al-Mosaind, Dueker, and Strathman (1993) estimated that single-family homes located within a 500-meter walk of stations on Portland's light-rail system sold at a premium of $4,324 (or over 10 percent) when compared with otherwise similar homes beyond that distance.

Other transit capitalization studies have produced estimates somewhere between these two extremes. In Vancouver, Ferguson (1988) estimated an accessibility price premium of $4.90 (Canadian) per foot of distance from the closest light-rail station, but only for those homes within one-half mile of the line. In Atlanta, Nelson (1992) found that transit accessibility increased home prices in lower-income census tracts, but decreased values in upper-income tracts. In Philadelphia, Voith (1991) found that home prices in census tract served by the PATCO commuter rail system were 10 percent higher than home prices in unserved tracts.

BART is perhaps the single most studied transit system in the country. BART began partial East Bay service in 1972, with full Transbay service following in 1975. Two preliminary studies by Dornbusch (1975) and Burkhardt (1976) noted reduced property values around some BART station areas — a finding they attributed to increased noise and auto congestion. In a survey of homeowners, Baldassare et al. (1979) found a reduced preference for homes near elevated BART station. By contrast, Blayney Associates (1978) concluded that BART had a small but significant positive effect on prices of single-family homes within 1000 feet of some (but by no means all) stations. Owing to the relative newness of the BART system at the time these four studies were conducted, their results should be regarded as preliminary.

2.5. Summary

There are few areas in which theory and empirical observation are more divergent than in the analysis of how transportation investments affect land-use patterns and property values. Economic theory (and to a lesser extent urban geography) suggest that highway and transit investments should have a strong effect on nearby land uses and property values, and, depending on the form and scale of the investment, a moderate impact on regional land-use patterns.

Modern emprical studies, by contrast, tend to be far more modest in their findings. A few highway studies have indicated a high level of localized and regional impact; most suggest that the impacts of highway investments tend to be limited and localized. Still others find no effect at all. Turning to transit, no contemporary study finds that recent transit investments have had significant development or price impacts at any level.

We offer two explanations of these various discrepancies. First, mirroring Trygg and Knight, we suggest that localized institutional and political factors — particularly local zoning — are far more important than commonly thought in limiting the land development and property value impacts of transportation investments. Second, we suggest that the land development and property value impacts associated with transportation investments follow their own "product-cycle" curve. Specifically, the spatial effects of transportation technologies are greatest when those technologies are new, and then decline over time. New transportation technologies radically alter accessibility, and in doing so, transform the economics of urban areas. That is, they generate areas that are radically underpriced. Once the higher value of such areas becomes apparent, land developers, businesses, and households respond swiftly. Previously underpriced areas are quickly developed, and the land market quickly reaches a new equilibrium predicated on the new transportation technology. Historical evidence suggests that this adjustment process takes place quickly, over the course of a few years. Once the higher equilibrium price has been established, the potential for additional development or price increases is substantially reduced.

This theory suggests that new transportation investments will have their greatest effects on metropolitan land uses during the initial years of the technological diffusion. For rail transit, this period was the first two decades of the 20th century. For the automobile, the diffusion period was interrupted by the Depression and so, lasted considerably longer, from 1930 through the mid-1960s. Once the diffusion period is past, and the technology established, additional transportation investments (within that same technology) will have only small impacts — so small that they may ultimately be marginalized by conservative land-use policies designed to preserve the pre-investment status quo.

CHAPTER THREE:
Rail Transit Access and Single-Family Home Prices

by John Landis, Subrajit Guhathakurta, and Ming Zhang

Urban economists have long noted the contribution of transportation investments to higher property values. This chapter explores the extent to which BART, CalTrain, the San Diego Trolley, and light-rail systems in San Jose and Sacramento currently contribute to higher single-family home prices in their respective service areas. Section 3.1 presents the basic *hedonic capitalization* model, and explains the variables included in the model. Section 3.2 applies the model to homes in Alameda, Contra Costa, and San Mateo counties served by BART and CalTrain. Section 3.3 applies the model to homes in the City of San Diego served by the San Diego Trolley, and to homes in San Jose and Sacramento served by those cities' light-rail systems.

3.1. Model Development and Specification

Hedonic Price Theory and Modeling

As noted in Chapter Two, most recent transport capitalization studies are based in hedonic price theory. Hedonic price theory assumes that many goods are a combination of different attributes, and their transaction prices can be statistically decomposed into the component (or "hedonic") prices of each attribute (Rosen, 1974; Freeman, 1979). Housing sales prices, for example, can be decomposed into separate attribute prices for shelter services, financial services, and location. Shelter services reflect the physical size, quality, and design of the housing unit, and are invariant with respect to the homeowner. Financial services include the tax shelter and appreciation benefits associated with homeownership, and vary according to the characteristics of both house and owner. Locational services include neighborhood quality as well as the combination of taxes and public goods associated with a particular homesite's location. Accessibility is generally viewed as a locational service, and is commonly measured in terms of travel time or travel distance between the home and some combination of work or non-work opportunities.

Hedonic prices are estimated statistically, usually using regression analysis. Hedonic price models have been used to test for the existence of relationships between housing prices and a wide variety of neighborhood attributes, including: environmental quality (Thayer, Albers, and Rahmatian; 1992); distance from landfills (Smolen, Moore, and Conway; 1992); tax incidence (Chadry and Shah, 1989); noise pollution (Langley, 1976); and proximity to non-residential land uses (Grether and Mieszkowski, 1980).

The hedonic price models estimated in this chapter all follow the same general form:

1990 Single-Family Home Sales Price*(i)*

= f[Home attributes *(i)*,
Neighborhood quality variables*(i)*,
Transportation accessibility variables *(i)*]

where *i* indicates a specific home sale.

Housing and Neighborhood Quality Attributes

Home sales prices and attributes were extracted from the TRW-REDI data service for six representative samples[8] of 4,180 single-family home transactions in Alameda, Contra Costa, Sacramento, San Diego, San Mateo, and Santa Clara counties for the second quarter of 1990.[9] In addition to the home sales prices (*SALEPRICE*), five measures of home quality were extracted:

1. *Square footage of living area (SQFT): SQFT* measures the living area size of each home, excluding garage, porch, and deck space. All else being equal, one would expect this variable to be positively correlated with home prices: the larger the home, the more expensive it is likely to be. Previous hedonic price models have usually revealed this variable to be the single best predictor of home prices.
2. *Lot area in square feet (LOTSIZE):* All else being equal, we would expect households to prefer larger lots.
3. *Home age (AGE):* Depending on the city, this variable may be positive or negative. In neighborhoods where older homes are prized for their architectural or historical value, one would expect this variable to be positively correlated with price: the older the home, the higher the price it is likely to bring. In more modern neighborhoods, where older homes are smaller or less functional (by modern standards), this variable may have a negative sign.
4. *Number of bedrooms in the home (BDRMS):* By itself, this variable should be positively correlated with home price: all else being equal, the more bedrooms a home has, the larger and more expensive it is likely to be. Difficulties of interpretation arise, however, when *BDRMS* is included in hedonic price models together with *SQFT.* Since both variables measure home size, they are highly correlated. In markets where homebuyers place a premium on having more and larger bedrooms, *BDRMS* should be positive when coupled with *SQFT.* In markets where buyers prefer other types of space (e.g., kitchens or bathrooms), this variable may have a negative sign.
5. *Number of bathrooms in the home (BATHS):* Like bedrooms, this variable is positively correlated with price. All else being equal, the more bathrooms a home has, the larger and more expensive it is likely to be. When *BATHS* is included together with *SQFT*, however, the results may be different. In markets where homebuyers place a premium on having more and larger bathrooms, *BATHS* should be positive when coupled with *SQFT.* In markets where buyers prefer other types of space (e.g., kitchens or bedrooms), or in which the typical home has a large number of bathrooms, this variable may have a negative sign.

Previous hedonic price studies have demonstrated that home prices are sharply reflective of neighborhood quality. The same house may sell at a tremendous premium if located in a high-income neighborhood with higher levels of public services, or at a tremendous discount if located in a blighted, deteriorating neighborhood. There are, of course, many ways to measure neighborhood quality. Past studies have utilized measures of income levels, public service frequency and quality, school achievement scores, indices of deterioration, and racial mix. This study identifies neighborhoods as census tracts, and draws on six census tract-based measures of neighborhood quality from the 1990 Census:[10]

6. *1990 census tract median household income (MEDINC90):* This variable measures the 1990 median household income of the census tract in which the home is located. All else being equal, one would expect this variable to be positively correlated with home prices: the higher the tract median income, the nicer the area, the more households should be willing to pay for housing. This is the demand side of the income variable. There is also, however, a "supply" side. Because most homes are financed, and because a household's income determines its ability to obtain financing, home prices are necessarily linked to household incomes. This is particularly true in census tracts or neighborhoods in which there is a large amount of housing turnover.[11] The fact that income enters hedonic price models on both the supply and demand sides means that it must be interpreted very carefully.
7. *Share of census tract households in 1990 that are homeowners (PctOWNER):* This variable, like income, above, can go both ways. On the demand side, one might expect that homebuying households would be willing to pay a premium to live in communities of people similar to themselves: homeowners. Thus, one might expect this variable to be positively correlated with home prices. An opposite effect would occur on the supply side: the lower the homeownership rate, the fewer the number of available homes for purchase, the more dear such homes are likely to be.

8-11. *Share of census tract population in 1990 that was African-American (PctBLACK); Asian (PctASIAN); Hispanic (PctHISP); and White (PctWHITE):* We begin with the assumption that most households have a preference to live in the midst of communities of similar color (holding socio-economic characteristics such as income and age constant). Black households would thus be expected to pay a premium to live in census tracts with a significant Black population; White households should be willing to pay a premium to live in white-majority tracts, and so on. The problem with testing this assumption is that we typically lack information on the race or ethnicity of particular buyers.

A second-best hypothesis is that most households, regardless of their race, would prefer to live in a white-majority tract. This has less to do with social preferences, per se, than with the recognition that homes in white-majority tracts have tended to appreciate at a faster rate than homes in non-white-majority tracts. Depending on the city, this variable may be positive or negative. Applying this theory, we would expect to find a positive correlation between housing prices and Pct*WHITE*, but a negative correlation between housing prices and *PctBLACK*, Pct*ASIAN*, and *PctHISP*. To the extent that we do not find such correlations, or find them to be statistically insignificant, one might conclude that housing prices and neighborhood racial make-up are unrelated.

Measuring Transportation Accessibility

Proximity to any sort of transportation facility is a two-edged sword. On one side, homes located adjacent to or nearby a highway or rapid transit line usually have excellent accessibility. On the other side, homes located right next to major transportation facilities must also suffer such disamenity effects as noise, vibration, and in the case of highways, localized concentrations of pollution. Homes located far away from transportation facilities can avoid such disamenities, but must sacrifice accessibility.

All else being equal, one would expect accessibility to be positively capitalized into home values: homes located near transit stations and highway interchanges should sell at a premium when compared with similar homes located further away. Similarly, one would expect the disamenity effects of being located too near a transit line or freeway to be negatively capitalized into property values; homes located adjacent to such facilities should sell at a discount when compared with comparable homes located at a distance. The extent of capitalization will depend in part on the configuration and design of the transportation facility. Commuter rail lines, for example, may have fairly sizeable disamenity zones, as may some types of at-grade highways. By contrast, underground transit lines or above-grade freeways may minimally impact neighboring land uses.

Four measures of transportation accessibility and proximity were included in the various hedonic price models:

12. *Roadway distance from each home to the nearest rapid transit station (TRANDIST):* *TRANDIST* measures the minimum distance along local roads from each home in the data set to the nearest rapid transit station. A negative value for *TRANDIST* (the expected result) means that homes located near transit stations would sell at a premium compared with homes located further away.
13. *Roadway distance from each home to the nearest freeway interchange (HWYDIST):* *HWYDIST* measures the minimum distance along local roads from each home in the data set to the nearest rapid transit station. A negative value for HWYDIST (the expected result) means that homes located near transit stations would sell at a premium compared with homes located further away.
14. *Adjacency to the nearest rapid transit line (TRANADJ):* *TRANADJ* is a dummy variable coded to one if a house is within 300 meters of an above-ground transit line, and zero otherwise. A negative value for *TRANADJ* (the expected result) means that homes located within 300 meters of surface transit lines would sell at a discount when compared with homes located further away.
15. *Adjacency to the nearest freeway (HWYADJ):* *HWYADJ* is a dummy variable coded to one if a house is within 300 meters of an above-ground freeway, and zero otherwise. A negative value for *HWYADJ* (the expected result) means that home located within 300 meters of surface transit lines would sell at a discount when compared with homes located further away.

Measuring each of these four variables by hand using paper maps for anything more than a handful of homes would be an impossibly arduous task. Instead, ARC/Info, a geographic information system (GIS), was used to locate each home, transit line and station, and highway and interchange, and to measure the various distances. The GIS procedures used for this task are summarized in Appendix A. Table 3.1 reviews the variable data sources and summarizes the mean values of the model variables for each county.

Table 3.1: Mean Values of the Model Variables by County Sample

Variable	Units	Data Source	Alameda	Contra Costa	Sacra-mento	San Diego	San Mateo	Santa Clara
			County					
1990 Saleprice	1990$	TRW-Redi	$233,600	$238,902	$157,176	$207,297	$334,195	$289,828
Home Square Footage (SQFT)	sqft	TRW-Redi	1447	1706	1513	1635	1437	1591
Lotsize	sqft	TRW-Redi	6,545	9,756	29,726	15,242	6,383	7,991
Home Age (AGE)	years	TRW-Redi	44.6	25.5	23.1	24.7	38.5	30.3
# of Bedrooms (BEDRMS)	#	TRW-Redi	3.0	3.3	3.2	3.2	2.9	3.4
# of Bathrooms (BATHS)	#	TRW-Redi	1.6	1.9	1.9	1.9	1.6	1.9
Median Census Tract Household Income (MEDINCOM)	1989$	1990 Census	$45,041	$50,051	$36,687	$42,242	$49,270	$54,324
% of Population-White (PctWHITE)	%	1990 Census	66%	78%	76%	83%	72%	71%
% of Population-Asian (PctASIAN)	%	1990 Census	13%	10%	10%	6%	17%	17%
% of Population-Black (PctBLACK)	%	1990 Census	15%	8%	9%	3%	6%	3%
% of Population-White (PctHISPN)	%	1990 Census	14%	11%	10%	17%	16%	18%
% Homeowners (PctOWNER)	%	1990 Census	65%	73%	64%	67%	64%	69%
Home to Transit Station Network Distance (TRANDIST)	meters	Arc/INFO	6,392	11,682	6,844	28,927	5,290	8,508
Home to Frwy Interchange Network Distance (HWYDIST)	meters	Arc/INFO	1,993	3,320	3,475	3,817	2,514	2,657
Within 300m of Transit Line (Dummy variable: TRANADJ)		Arc/INFO	0.05	0.03	0.05	0.01	0.11	0.01
Within 300m of Freeway (Dummy variable: HWYADJ)		Arc/INFO	0.27	0.10	0.06	0.09	0.15	0.09
Number of Observations			1132	1229	942	1129	236	1367

3.2. The Capitalization Effects of Heavy Rail Systems: BART and CalTrain

We divide our analysis of the housing price effects of transit accessibility/proximity into two sections. In this section, we consider the housing price capitalization effects of two heavy-rail systems, BART and CalTrain. Both systems span multiple counties and political jurisdictions. The next section examines the housing price capitalization effects of three light-rail systems: San Diego, Sacramento, and San Jose.

Our analysis of the capitalization effects of BART and CalTrain is itself organized into two parts: (i) a common model specification applied separately to home sales in Alameda, Contra Costa, and San Mateo Counties; and (ii) unique, "best-fit" model specifications for each county.

Common Model Specification

We begin with the common specification (Table 3.2). The three regressions, one each for Alameda, Contra Costa, and San Mateo Counties, include exactly the same variables, regardless of their statistical significance. This allows us to determine the explanatory power of a single specification in three somewhat different housing markets.

Table 3.2: Capitalization Effects of Heavy Rail Transit Investments on Single Family Home Prices: Common Specification for Alameda, Contra Costa, and San Mateo Counties

Dependent Variable: SALEPRICE (1990)

	Alameda County		Contra Costa County		San Mateo County	
	Coefficient	t - stat	Coefficient	t - stat	Coefficient	t - stat
Home Characteristics:						
SQFT	**110.62**	**27.48**	**107.37**	**22.91**	**145.71**	**8.92**
LOTSIZE	**1.81**	**5.79**	**2.51**	**12.71**	**4.17**	**3.26**
BATHS	3,768.88	1.23	297.03	0.07	**27,397.66**	**2.25**
AGE	91.63	1.00	2.08	0.02	-16.19	-0.04
BEDRMS	**-5,523.37**	**-2.20**	**-13,335.03**	**-4.60**	**-27,134.33**	**-2.84**
Neighborhood Characteristics:						
MEDINCOM	**2.10**	**12.02**	**2.21**	**10.81**	**1.57**	**3.87**
PctWHITE	-125,164.75	-1.62	-88,629.47	-1.02	808.02	0.23
PctASIAN	**-175,514.43**	**-2.21**	-61,199.46	-0.70	-256.26	-0.07
PctBLACK	**-214,791.49**	**-2.66**	-138,114.63	-1.55	-207.94	-0.06
PctHISPN	**-225,039.93**	**-4.14**	**-143,943.67**	**-2.78**	-147.49	-0.12
PctOWNER	**-57,769.56**	**-4.92**	**-85,097.96**	**-4.73**	**-65,855.08**	**-2.09**
Locational Characteristics:						
HWYDIST	**2.80**	**2.30**	**3.41**	**6.48**	4.41	1.15
TRANDIST	**-2.29**	**-10.50**	**-1.96**	**-8.78**	-2.61	-1.17
HWYADJ	-108.43	-0.03	631.86	0.11	-6,217.90	-0.04
TRANADJ	5,240.62	0.81	10,484.16	1.00	-31,424.99	-1.62
CONSTANT	**182,376.87**	**2.23**	138,127.16	1.58	55,308.08	0.16
R -squared	0.80		0.76		0.64	
Observations	1131		1228		232	

Note: Coefficients in bold print are significant at the 95% confidence level.

The common model fits the data fairly well, explaining 80 percent of the variation in the sample of Alameda home prices, 76 percent of the variation in the sample of Contra Costa home prices, and 64 percent of the variation in the sample of San Mateo home prices. Given the size and diversity of the samples, these are very good measures of goodness-of-fit.

The value and statistical significance of the coefficients of the home attributes varies by county. Home square-footage (SQFT) is the most significant variable in all three counties, followed by lot square-footage (LOTSIZE). In Alameda County, every additional square foot of home size (above the mean) added \$110.62 to the price of a home sold in 1990. In Contra Costa County, every additional square foot of living area added \$107.37. And in San Mateo County, the estimated hedonic price of an additional square foot of living area was \$145.71. The coefficient for the number of bedrooms (BDRMS) was statistically significant and consistently negative in all three counties. This result does not mean that homes with more bedrooms sell at a discount. It does mean that buyers prefer their additional square footage in a form other than as additional bedrooms. Homebuyers in Alameda and Contra Costa

County were unwilling to pay a premium for additional bathrooms (above the average), in contrast to homebuyers in San Mateo County, who were willing to pay $27,398 additional dollars for an additional bathroom. The coefficient for the variable measuring home age (AGE) was not statistically significant in any of the three counties.

The six variables describing neighborhood income and racial make-up also vary in importance and significance by county. Of the six variables, only two are consistently significant: 1990 median family income (MEDINC), and the owner-occupied share of the housing stock (PctOWNER). As with the case of square footage and bedrooms above, this does not mean that houses in neighborhoods with the case of square footage and bedrooms above, this does not mean that houses in neighborhoods with a preponderance of owner-occupied homes sell at a discount. Rather, it is because income, not housing tenure, is regarded as the primary measure of neighborhood quality. All else being equal, homes sell for more because they are in wealthy neighborhoods, not because they are in neighborhoods dominated by owner-occupied housing.

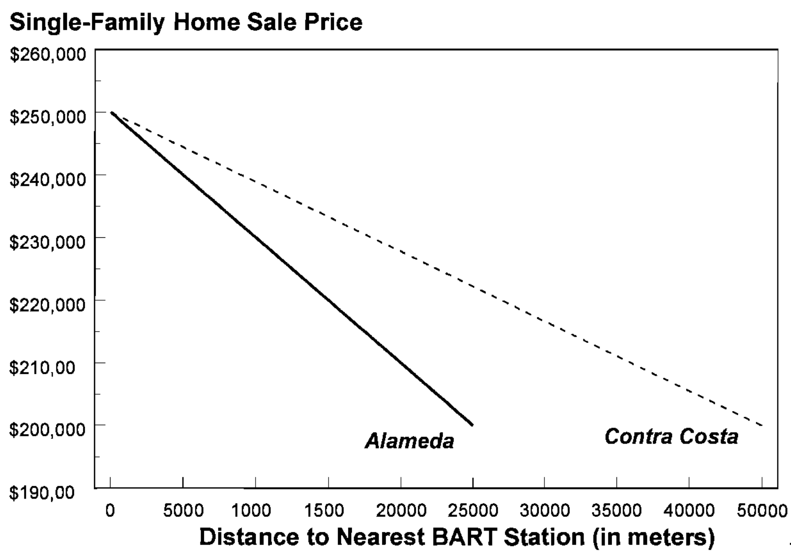
The coefficients of the various race variables also require some explanation: although they vary in significance by county, all are consistently negative, even for white-dominant census tracts. As above, this is the result of multicollinearity — in this case between racial make-up and income. In Alameda County, homes in Hispanic-dominant and African-American-dominant census tracts sell at a deep discount when compared with similar homes in white-dominant neighborhoods. Homes in Asian-dominant census tracts also sell at a discount compared to white-dominant neighborhoods. Race is considerably less important in Contra Costa County, where the only homes which sell at a discount are those in Hispanic-dominant census tracts. Finally, in San Mateo, neighborhood racial composition and home prices are statistically unrelated.

We turn now to the four variables measuring transportation access and proximity. The two proximity variables measuring the potential disamenity effects of transit and highways, TRANADJ and HWYADJ (measuring whether or not a particular home is within 300 meters of a transit line or freeway, respectively), are statistically insignificant for all three counties. This means that houses within 300 meters of major transportation facility did not sell at a discount in 1990 when compared with comparable homes located elsewhere. Put another way, there is no systematic disamenity effect associated with living near either BART, CalTrain, or a major freeway.

The two accessibility variables, TRANDIST and HWYDIST, by contrast are statistically significant, at least for homes in Alameda and Contra Costa counties that sold in 1990. Homes near BART stations sold at a premium in 1990, while homes near freeway interchanges sold at a discount. For every meter closer an Alameda county home was to the nearest BART station (measured along the street network), its 1990 sales price increased by $2.29, all else being equal. For Contra Costa homes that sold in 1990, the sales price premium associated with the nearest BART station was $1.96 per meter. The results for San Mateo County and CalTrain are different: accessibility to a CalTrain station did not boost the prices of San Mateo County homes sold in 1990.

The important contribution of BART accessibility to home prices in Alameda and Contra Costa counties is shown graphically in Figure 3.1. Holding all other home and neighborhood characteristics constant (and evaluated at their average values), home prices in Alameda County vary from $250,000 for homes immediately adjacent to a BART station, to $180,000 for homes located 35 kilometers (or about 20 miles) from a BART station. In Contra Costa County, homes directly adjacent to BART stations sell at a premium of $68,600 compared with otherwise similar homes located 35 kilometers distant.

Figure 3.1: Distance Decay Functions of Family Home Sale Prices: Alameda and Costa Counties, 1990



In the case of freeway accessibility (measured as street distance to the nearest interchange), the opposite effect was observed: in Alameda and Contra Costa Counties, homes near freeway interchanges sold for less than comparable homes elsewhere. For every meter it was closer to a freeway interchange, the 1990 sales price of an Alameda county home declined $2.80. The per-meter discount associated with highway accessibility was even greater in Contra Costa County: $3.41. Highway accessibility had no effect on the 1990 sales prices of San Mateo County homes.

Incorporating Inter-Jurisdictional Differences

A second set of regression models includes a unique "best" model for each county (Tables 3.3, 3.4, and 3.5). Here, in addition to the home, neighborhood, and transportation variables included above, we also include dummy variables for each incorporated city. This allows us to capture the price effects of municipal variations in tax rates, and school and public-facility quality, as well as to account for the possibility that at least some of the accessibility premiums previously attributed to BART (reported in Table 3.2) might be the result of inter-municipal service quality differentials. If homes near BART, for example, are located in cities which provide a higher quality of public services at a lower tax cost then elsewhere, then the BART accessibility premiums estimated above would be significantly over-stated. To test for this possibility, we included dummy variables in the various specifications denoting which municipality a particular home was located in. After first estimating each model with a full set of city dummy variables, we then eliminated all variables found to be statistically insignificant. The best model for each county selects only those explanatory variables that are significant at the 95 percent confidence level. As a result, only the significant locational variables are reported.

Six Alameda County municipal dummy variables were found to be statistically significant: *ALAMEDA*, *ALBANY*, *BERKELEY*, *OAKLAND*, *PIEDMONT*, and *UNION CITY*. The estimated coefficients are effectively the price premiums associated with a particular home being located in a specific city. Homes in Piedmont, for example, sold for $100,502 more in 1990 than comparable homes located elsewhere in Alameda County. Inserting the municipal dummy variables in the model reduces the statistical significance of the highway accessibility variable (*HWYDIST*), but it has a negligible effect on the transit station accessibility variable (*TRANDIST*). All else being equal, homes in Alameda County sold at a $1.91 premium in 1990 for every meter they were located closer to a BART station. Put another way, for every kilometer further distant a house was from a BART station in 1990, its price declined by about $2,000.

The price effects of municipal service and tax differential are more apparent in Contra Costa County, where almost all of the municipal dummy variables were found to be statistically significant (Table 3.4). Compared to comparable homes located in unincorporated Contra Costa County, homes located in Orinda, Kensington, Moraga, and Lafayette sold at premiums of $26,745, $40,041, $47,885, and $28,241, respectively. Comparable homes in other municipalities sold at discounts, ranging from a minimum discount of $38,739 in Walnut Creek, to a maximum discount of $132,185 in Antioch. Including the municipal dummy variables raises the overall goodness-of-fit of the model from .76 (for the common specification shown in Table 3.4) to .83.

Not surprisingly, the municipal dummy variables are correlated with the two transportation accessibility variables. Compared with the common specification in Table 3.2, inserting the municipal dummy variables in the model renders the highway accessibility variable (*HWYDIST*) insignificant, while reducing the premium associated with being near BART — from $1.96 per meter to $1.04 per

Table 3:3: Capitalization Effects of BART on 1990 Alameda County Single-Family Home Prices

Dependent Variable: SALEPRICE (1990)

	Alameda County	
	Coefficient	t - stat
Home Characteristics:		
SQFT	100.73	34.28
LOTSIZE	2.41	8.33
AGE	-548.07	-5.72
Neighborhood Characteristics:		
MEDINCO	1.64	9.57
PctWHITE	88,594.87	-1.62
PctHISPN	-48,852.69	-2.40
PctBLACK	-47,710.62	-2.66
PctOWNER	-53,241.79	-4.94
Locational Characteristics:		
TRANDIST	-1.91	-9.61
City Dummy Variables		
BERKELEY	68,817	11.36
OAKLAND	50,379	9.71
ALAMEDA	102,201	7.13
PIEDMONT	100,502	6.48
ALBANY	53,697	4.95
UNION	24,208	2.62
CONSTANT	-1,022.00	-0.06
R -squared	0.83	
Observations	1132	

meter. The coefficients of the two transportation adjacency variables, *HWYADJ* and *TRANADJ*, remain statistically insignificant.

Inserting the various municipal dummy variables also affects the values and significance levels of the home and neighborhood coefficients. Compared to the common specification shown in Table 3.2, the *SQFT*, *LOTSIZE*, and *BEDROOMS* coefficients are reduced in magnitude, while the AGE variable becomes statistically significant. Inserting the municipal dummy variables renders the *MEDINCOM*, *PctHISPANIC*, and *PctOWNER* variables statistically insignificant at the same time that the *PctBLACK* and *PctASIAN* variables become statistically significant.

In San Mateo County, including the various municipal dummy variables increases the overall goodness-of-fit from .64 to .72 (Table 3.5). Eight municipal dummy variables are statistically significant in San Mateo County: Woodside, Millbrae, San Carlos, Burlingame, Menlo Park, Belmont, Redwood City, and San Mateo. Compared to San Mateo County as a whole, price premiums vary from a high of $4,564,422 for Woodside, to a low of $51,732 in San Mateo.

Table 3.4: Capitalization Effects of BART on 1990 Contra Costa County Single-Family Home Prices

Dependent Variable: SALEPRICE (1990)

	Contra Costa County	
	Coefficient	t - stat
Home Characteristics:		
SQFT	93.22	25.16
LOTSIZE	2.33	13.50
BEDRMS	-8,218.73	-3.24
AGE	-932.34	-7.85
Neighborhood Characteristics:		
MEDINCOM	0.24	1.67
PctASIAN	-108,747.98	-2.40
PctBLACK	-55,319.85	-3.60
Locational Characteristics:		
TRANDIST	-1.04	-3.44
HWYDIST	1.32	1.80
City Dummy Variables		
MORAGA	47,885	3.72
KENSINGTON	40,041	2.36
LAFAYETTE	28,241	2.62
ORINDA	26,745	1.98
DANVILLE	-23,102	-2.17
SAN RAMON	-34,307	-3.07
WALNUT	-38,739	-4.45
BETHEL	-63,186	-2.63
CLAYTON	-68,037	-3.79
PLEASANT	-69,146	-6.83
BYRON	-70,973	-5.19
CROCKETT	-80,106	-3.93
RICHMOND	-80,439	-9.12
PINOLE	-82,726	-8.62
MARTINEZ	-91,522	-9.50
SAN PABLO	-92,544	-9.78
CONCORD	-98,229	-11.65
EL SOBRANTE	-100,593	-7.76
PACHECO	-104,628	-2.14
RODEO	-105,543	-4.58
OAKLEY	-124,073	-11.54
PITTSBURG	-127,176	-14.08
ANTIOCH	-132,185	-13.63
BRENTWOOD	-136,089	-11.18
CONSTANT	195,342.77	13.14
R -Squared	0.83	
Observations	1229	

Compared to the common specification shown in Table 3.2, including the municipal dummy variables has no effect on the transit accessibility (*TRANDIST*) or highway proximity variable (*HWYADJ*), but has a big effect on the highway accessibility (*HWYDIST*) and transit proximity (*TRANADJ*) varia

Table 3.5: Capitalization Effects of Caltrain Service on 1990 San Mateo County Single-Family Home Prices

Dependent Variable: SALEPRICE (1990)

	San Mateo County	
	Coefficient	t - stat
Home Characteristics:		
SQFT	128.19	8.17
LOTSIZE	3.30	2.88
BEDRMS	-26,138.00	-2.96
BATHS	37,432.00	3.47
Neighborhood Characteristics:		
MEDINCOM	0.92	3.11
PctBLACK	-975.30	-2.24
Locational Characteristics:		
TRANADJ	-51,011.36	-2.71
HWYDIST	4.68	2.13
City Dummy Variables		
WOODSIDE	4,564,422	6.29
BURLINGAME	129,936	5.11
MILLBRAE	111,717	3.63
MENLO PARK	87,240	3.96
BELMONT	66,464	2.98
SAN CARLOS	66,163	2.63
REDWOOD	53,594	3.64
SAN MATEO	51,732	3.44
CONSTANT	59,004.00	2.40
R -Squared	0.72	
Observations	233	

bles; both become statistically significant. According to the results shown in Table 3.5, for every meter a San Mateo County home was closer to a major freeway, its 1990 sales price declined by $4.68. Clearly, homebuyers in San Mateo County are willing to pay a premium *not* to be near a freeway. They are also willing to pay money not to be located within 300 meters of the CalTrain right-of-way. All else being equal — including neighborhood income, racial composition, and municipal service level — homes located within 300 meters of the CalTrain line sold at a discount in 1990 of $51,011. The disamenity value associated with living near the CalTrain line is probably a function of the noise levels generated by CalTrain service, noise levels that are much higher than BART's. Note also that while BART is undergrounded in some communities and contained by a freeway in others, CalTrain runs at-grade for its entire length.

These results pose two basic questions. The first is why there should be a price premium associated with accessibility to BART stations but not CalTrain stations. We believe that the answer lies with BART's superior level of transit service and greater parking capacity. Because of its greater speed, more frequent service, and ability to accommodate a wider commuter shed through large amounts of parking, BART generates true accessibility advantages for large areas of Alameda and Contra Costa Counties. CalTrain service, by contrast, is more limited, and is targeted toward a relatively small number of commuters in San Mateo and Santa Clara Counties.

A second question is why accessibility to BART stations should generate a housing price premium, while accessibility to freeway interchanges does not. We believe the reason is that freeway access in the Bay Area is fairly ubiquitous: regardless of where one lives or works, a freeway interchange is almost sure to be nearby. Compared to BART access, which is a relatively scarce commodity, freeway access is a relatively plentiful one. Thus, few households are willing to pay extra for it.

3.3. Three Light-Rail Systems

Table 3.6 presents the results of the common model specification presented in Table 3.2 as applied to home sales around California's three light-rail systems: Sacramento, San Diego, and San Jose. In contrast to BART accessibility, accessibility to a light-rail station does not appear to significantly increase home values. Of the three light-rail systems, only the San Diego Trolley shifted home prices in its favor. San Jose's transit system had the opposite effect, with average home prices actually declining with increasing proximity to transit stations. The third light-rail system in our analysis, Sacramento transit, had no significant effect on home prices.[12] These results are explored in greater detail below.

The San Diego Trolley

Of the three light rail transit systems examined in this study, the San Diego Trolley is the most successful. It has the highest ridership, and as recently as 1993, recovered almost 90 percent of its operating cost from the farebox.

Applied to a sample of 134 home sales in the City of San Diego in 1990, the common model specification explains 83 percent of the variation in home prices. Of the five home characteristic variables included in the model, only two, SQFT and AGE, are statistically significant. By contrast, all six of the neighborhood characteristic variables are statistically significant.

Of the four transportation accessibility and proximity variables included in the model, only one, *TRANDIST*, is statistically significant and of the expected sign. For the typical single-family home in the City of San Diego in 1990, for every meter it was closer to a Trolley station, its 1990 home price increased by $2.72. Note that this premium is actually higher than the accessibility premiums associated with BART stations.

The premium associated with accessibility to a Trolley station applies only to homes in the City of San Diego. If the home sales data set is expanded to include home sales outside the city, TRANDIST becomes statistically insignificant. This suggests that while the accessibility premium associated with the San Diego Trolley is quite high, it is limited in extent to homes in the City of San Diego. This is quite different than the BART case above, where the extent of the accessibility premium is more far-reaching.

Table 3.6: Capitalization Effects of Light Rail Transit Investments on Single Family Home Prices: Common Specification for Sacramento, San Diego, and San Jose Cities

***Dependent Variable*:** SALEPRICE (1990)

	Sacramento City		San Diego City		San Jose	
	Coefficient	t - stat	Coefficient	t - stat	Coefficient	t - stat
Home Characteristics:						
SQFT	**96.07**	**17.86**	**58.15**	**6.33**	**109.42**	**24.83**
LOTSIZE	0.00	-0.56	-0.21	-1.02	**6.23**	**10.89**
BATHS	7,649.00	1.49	9,003.48	1.10	-2,608.57	-0.07
AGE	1,349.02	8.99	**-2,065.19**	**-4.41**	25.72	0.18
BEDRMS	**-12,872.00**	**-4.01**	5,378.64	1.00	1,589.39	1.38
Neighborhood Characteristics:						
MEDINCO	**2.59**	**6.12**	**2.52**	**5.61**	0.23	-0.74
PctWHITE	-58,204.00	-0.49	**-5,606.46**	**-2.50**	22,064.05	0.41
PctASIAN	-7,360.00	-0.06	**-8,035.42**	**3.57**	51,093.00	0.90
PctBLACK	-102,841.00	-0.85	**-10,942.52**	**-3.37**	**-672,046.28**	**-7.38**
PctHISPN	**-217,132.43**	**-2.52**	**-4,885.02**	**-3.05**	-44,194.17	-1.27
PctOWNER	**-105,175.00**	**-5.83**	**723.42**	**-2.53**	**-600.42**	**-3.75**
Locational Characteristics:						
HWYDIST	-1.66	-1.01	**-1.85**	**-0.44**	**4.41**	**1.15**
TRANDIST	-0.65	-0.73	**-2.72**	**-3.78**	**-2.61**	**-1.17**
HWYADJ	-10,537.82	-1.35	6,560.96	0.73	-6,217.90	-0.04
TRANADJ	9,668.75	1.23	-8,391.97	-0.42	-31,424.99	-1.62
CONSTANT	182,376.87	2.23	138,127.16	1.58	55,308.08	0.16
R -squared	0.80		0.76		0.64	
Observations	1131		1228		232	

Note: Coefficients in bold print are significant at the 95% confidence level.

San Jose

Perhaps because of its newness, the San Jose light-rail system has yet to have had much of an impact. Ridership remains quite low, as do rates of farebox recovery.

Nor, judging from the results of the common model, has the San Jose system had a positive impact on nearby home prices. Quite the contrary. Transit in San Jose actually *takes away* value from homes that are located within easy reach of its stations. The decline in average home prices in San Jose is about \$1.97 per meter of distance between a home and the nearest transit station. As large as this number is, it is considerably less than the discount associated with proximity to the nearest freeway interchange: for every meter the typical home was closer to a freeway interchange, its 1990 sales price declined by \$4.36. San Jose homes within 300 meters of a freeway sold at an additional discount of \$11,486.

What accounts for these results? Part of the reason San Jose homebuyers prefer not to live near transportation facilities (whether transit or highways) is that those facilities tend to be located in neighborhoods dominated by commercial and industrial uses. The housing stock located in such neighborhoods is simply less valuable. Over time, transit service may add value to the older housing stock, but as yet such an effect is not apparent. Equally important, unlike BART, CalTrain, and to a lesser extent, the San Diego Trolley, San Jose's light-rail stations are designed for pedestrian and bus access, and include only minimal amounts of parking. This significantly reduces the system's ability to attract patronage from San Jose's more affluent, outlying areas.

Sacramento

Sacramento's light-rail system is similar in many respects to those in San Diego and San Jose. The system is of the same vintage, operates at roughly the same speeds, is not grade-separated, and primarily serves the downtown area. Unlike the San Jose system, Sacramento's light-rail system does pass through several established residential neighborhoods. Moreover, several of the system's outer stations are located in freeway medians, and include extensive amounts of parking.

Despite these advantages, Sacramento's light-rail system has had no discernable positive or negative effect on home prices within the city. This is also true for freeways. In fact, none of the four variables measuring transportation accessibility or proximity is even marginally significant. What drives housing prices in Sacramento is home size (larger homes sell at a significant premium), home age (older homes also sell at a premium), and neighborhood income levels.

This finding is not unexpected. Although nearly as long as the San Diego Trolley, Sacramento's light-rail system served 60 percent fewer passengers in 1991. As discussed above, the Sacramento system is also considerably less efficient than the San Diego Trolley in terms of both total operating cost and operating cost per passenger mile. Finally, Sacramento's freeways are far less congested than those in San Diego. Thus, the Sacramento light-rail system plays a far smaller role in providing congestion relief than does the San Diego Trolley.

3.4. Caveats and Conclusions

A Note on Temporal Stability

All of the models estimated above are based on 1990 home sales. To what extent might these results differ for other years? To explore the stability of the models over time we compared the results of the Alameda County and San Diego city models estimated using 1990 sales data with the results of a second set of model runs using 1987 sales data. The results of this latter set of runs is included as Appendix A.

Although the coefficients estimates in the 1990 models were expectedly higher (since we had not adjusted for inflation), overall there were no significant structural differences between the 1990 and 1987 estimates — for either the Alameda County or San Diego city samples. This comparison leads us to believe that our samples of 1990 single-family home sales are sufficiently representative of home sales in other periods to warrant our generalizations regarding the values of transit and highway accessibility.

Summary and Conclusions

This chapter compares the capitalization effects of transit and highway investments on single-family home prices across six California counties and five rail-transit systems. It breaks new ground in a number of areas. It is the first capitalization study of rail transit to compare multiple systems, and in particular, to compare heavy- and light-rail systems. It is one of only a handful of capitalization studies to compare accessibility to rail transit with accessibility to the primary competing mode: freeways. It is the first transit capitalization study to distinguish between the benefits of living *near a rail transit station* — improved accessibility — with costs of *living too near a transit route* — noise and vibration. Finally, it is the first capitalization study to exploit the analytic capabilities of geographic information systems to develop alternative measures of accessibility and proximity for use in hedonic modeling.

Beyond issues of methodology and technique, this chapter presents four significant findings regarding the nature and extent of transport capitalization:

1. The capitalization effects of rail transit can be significant. Among 1990 Alameda County home sales, the price premium associated with (street) distance to the nearest BART station was $2.29 per meter. For 1990 home sales in next-door Contra Costa County, the price premium associated with distance to the nearest BART station was $1.96 per meter.
2. Not all regional transportation facilities generate capitalization benefits. In none of the six counties studied did accessibility to a freeway interchange increase home prices. Quite the contrary. In Contra Costa and San Mateo counties, as well as in the city of San Jose, proximity to a freeway was associated with lower overall home prices.
3. The extent to which transit service is capitalized into increases in home prices depends on many things. First, and foremost, we believe, it depends on the quality of service. Regional systems such as BART, which provide reliable, frequent, and speedy service, which serve a large market area, and which are able to capture that market by providing parking, are more likely to generate significant capitalization effects. The San Diego Trolley also falls within this category. By contrast, systems which provide limited service (such as CalTrain), serve a limited market (San Jose Light Rail), lack parking for suburban commuters (Sacramento Light Rail), operate at slower speeds, or do not help reduce freeway congestion (Sacramento and San Jose Light Rail), are unlikely to generate significant capitalization benefits. The importance of service quality is corroborated by previous studies of the MARTA system in Atlanta (Nelson, 1992), and the Philadelphia Lindenwold line (Allen et al., 1986).
4. The negative externalities associated with being extremely close to an above-ground transit line (300 meters in this analysis) are not necessarily capitalized into home values. In only one of the five systems studied in the analysis — CalTrain — was proximity to the right-of-way associated with reduced home sales prices. Given that the CalTrain trackbed is minimally separated from adjacent uses, and that the CalTrain train cars are not specifically designed for quiet operation, this is not a surprising finding.

CHAPTER FOUR:
Rail Transit and Commercial Property Values

by John Landis and William Huang

Is transit service capitalized into commercial building and property values the same way it is capitalized into residential values? Do commercial sites and buildings near transit stations sell at higher prices than their more distant competitors? Contemporary urban economics suggests that they should: that commercial properties near transit stations have a competitive advantage over more distant buildings, and that the accessibility advantages associated with being near a mass transit station should be permanently capitalized into higher rents, higher occupancy rates, and ultimately higher property values. This chapter explores the extent of BART and San Diego Trolley service capitalization into commercial property sales price in Alameda and Contra Costa Counties (BART) and San Diego County (San Diego Trolley). Section 4.1 reviews the data and techniques used for this analysis. Section 4.2 pares average commercial sales prices by land-use category and rail station proximity. Section 4.3 introduces other factors that explain commercial sales prices, and Section 4.4 summarizes the various findings.

4.1. Data Issues

Empirical studies of transport capitalization into *commercial* property values are few and far between (Cervero and Landis; 1993; Cervero, 1993). The same sort of comprehensive, multi-year data used for residential capitalization studies is rarely available for commercial properties. Reported commercial transactions are often incomplete or include only partial sales prices.[13] Some land parcels are listed as multiple (subdivided) transactions, while others are listed singly.

A second data issue concerns coverage. Commercial land uses typically lie at the destination end of transit trips, and walking is the usual transit egress mode. With few transit riders (Cervero, 1994) willing to walk more than a quarter-mile to or from a station (for any purpose), the extent of any transit accessibility gradient is likely to be small. Data coverage — that is, the number of transacted properties close to a BART or San Diego Trolley station — must therefore be extremely high in order to identify — let alone estimate — a capitalization effect.[14]

Other problems are more theoretical in nature. When a home is sold, its value is determined in the marketplace: as a composite of the bid and reservation prices (of housing services) of all market participants. This is not always true for buyers and sellers of non-residential property; the value of a particular commercial transaction often reflects the characteristics or preferences of a single pair of buyers and sellers.

The commercial property data used in this analysis were culled from TRW-REDI's on-line real property files. The data set includes all full price commercial property transactions in Alameda, Contra Costa, and San Diego Counties between 1987 and 1993. The data set excludes partial-price sales, swaps, and un-reported intra-firm transactions. Reported information includes: (i) Property name and address; (ii) transaction date; (iii) major land use; (iv) property sales price; (v) lot size; (vi) building square footage; (vii) number of stories; (viii) time-of-sale assessed land values; and (ix) time-of-sale assessed structure value. To facilitate temporal comparisons, all sales prices and assessments were converted to 1983 dollars using the consumer price index.

Rather than measuring the airline or street distance from each property to the nearest BART or San Diego Trolley station (as in Chapter Three) we measured proximity in terms of "distance-rings." First, through a GIS technique known as address-matching,[15] each commercial property was located on a computerized street map. Next, a GIS program was used to identify which specific properties fell within one-quarter mile, within one-half mile, and beyond one-half mile of each BART and San Diego Trolley station.[16]

4.2. Alameda, Contra Costa, and San Diego Commercial Property Price Trends: Analysis of Variance

Table 4.1 summarizes average 1987-1993 Alameda, Contra Costa, and San Diego commercial property sales prices according to distance to the nearest rail transit station, and by land-use category. If proximity to BART or the San Diego Trolley is valued by buyers and sellers of commercial properties, then one would expect properties nearer BART and San Diego Trolley stations to sell at higher prices.

The extent to which this happens differs by county and land-use type. Consider the case of Alameda County office properties. The average 1987-1993 sales price of 14 Alameda County office properties closest to BART stations (within a quarter-mile) was $74.29 per square foot. The average sales price of 23 Alameda County office properties located in the next distance ring (1/4-mile to 1/2-mile from a BART station) was $42.27 per square foot. For Alameda County office properties more than a half-mile from a BART station, the average sales price was $30.44. These different values suggest that at least in Alameda County, BART station access *is* capitalized into office property prices.

To determine whether these differences are statistically significant, we undertook a statistical test known as analysis of variance. Analysis of variance (or ANOVA, as it more commonly known) is used to compare means across different groups. ANOVA compares variation between groups to variation within groups. The ratio of between-group variation to within-group variation in known as the F-ratio. If the F-ratio exceeds a given value (which itself varies according to the number of groups, and the number of observations in each group), the differences between group means are said to be statistically significant. Statistically significant differences are indicated in Table 4.1 in bold-face type.

Table 4.1: Analysis of Variance Results: 1988-93 Commercial Property Sales Prices (in 1983 Dollars) by Land Use Type and Proximity to a BART/San Diego Trolley Station

	Proximity to a BART/San Diego Trolley Station							
	<1/4 Mile		1/4-1/2 Mile		> 1/2 Mile		F -ratio	
County and Land Use	Avg.Land Price* per SQFT	# of Sales	Avg.Land Price* per SQFT	# of Sales	Avg.Land Price* per SQFT	# of Sales	F-ratio	Signif.
Alameda County Commercial Property Sales								
All Land Uses	$56.41	89	$37.52	144	$26.77	995	25.62	0.000
Office Uses	$74.29	14	$42.27	23	$30.29	154	13.11	0.000
Retail Uses	$62.27	43	$41.85	57	$34.06	316	11.30	0.000
Industrial Uses	$52.11	6	$26.56	24	$20.74	295	5.35	0.005
Auto-Oriented Uses	$14.43	1	$16.56	9	$19.47	37	0.04	0.963
Parking	$43.80	8	$32.12	14	$22.02	58	2.38	0.099
Vacant	$36.77	17	$46.86	16	$22.07	126	1.07	0.346
Contra Costa County Commercial Property Sales								
All Land Uses	$24.68	17	$35.53	71	$20.69	725	0.37	0.689
Office Uses	$17.71	6	$35.01	25	$26.75	127	0.97	0.383
Retail Uses	$39.40	5	$41.78	21	$22.16	150	6.16	0.003
Industrial Uses	n/a	0	$11.29	4	$11.61	109	0.00	0.963
Auto-oriented Uses	$15.25	1	$15.24	6	$19.22	37	0.20	0.819
Parking	$9.53	1	$78.07	6	$18.18	35	2.74	0.077
Vacant	$11.83	4	$20.39	8	$21.19	254	0.00	0.997
San Diego County Commercial Property Sales								
All Land Uses	$51.29	74	$24.97	83	$16.33	2495	0.84	0.430
Office Uses	$108.36	10	$34.14	6	$28.87	143	17.38	0.000
Retail Uses	$67.12	27	$26.67	33	$26.54	455	21.18	0.000
Industrial Uses	$32.67	16	$20.74	18	$20.27	217	0.87	0.422
Auto-oriented Uses	$13.32	3	$21.49	2	$19.36	47	0.56	0.576
Parking	$32.07	6	$31.68	4	$273.45	56	0.09	0.912
Vacant	$12.05	12	$23.25	19	$3.96	1552	14.55	0.000

Alameda County Commercial Property Sales: Just like office properties, retail and industrial properties near BART stations sold at higher per-square-foot prices than did more distant properties. The 43 retail properties located within a quarter-mile of a BART station sold at an average price of $62.27 per square foot, as compared with $41.85 per square foot for retail properties 1/4- to 1/2-mile from a BART station, and $34.06 per square foot for retail properties more distant than 1/2-mile. The prices of industrial properties, although significantly lower than retail or office prices, also declined with distance from a BART station. Moreover, as Table 4.1 shows, these various differences are all statistically significant. The same cannot be said for auto-oriented uses, parking uses, or vacant sites. The per-square-foot price of auto-oriented uses, parking uses, and vacant sites near BART stations were not systematically higher than the prices of more distant properties.

Contra Costa County Commercial Property Sales: Commercial properties close to BART stations in Contra Costa County did not sell at a premium between 1988 and 1994. Among the three BART station distance rings (less than a quarter-mile, 1/4- to 1/2- mile, and greater than 1/2-mile), commercial property prices were slightly higher in the middle ring, regardless of use. This effect is probably due to the fact that most BART stations in Contra Costa County are either between, or adjacent to, freeways. To the extent that properties very near BART stations are adjacent to freeways, the observed price discounts may in fact be associated with proximity to freeways, not BART stations.

San Diego Commercial Property Sales: With respect to proximity to transit, commercial property prices in San Diego County follow a similar pattern to those in Alameda County. Between 1988 and 1993, the prices of office and retail properties (per square foot of lot area) located near Trolley stations were consistently and significantly higher than the prices of more distant properties. For example, between 1988 and 1993, there were 10 transactions of office properties located within a quarter mile of a Trolley stop; the average price per square foot of these transactions was $108.36 (1983 dollars). During the same period, six office buildings located more than a quarter-mile but less than a half-mile from a Trolley stop transacted at an average price of $34.14 per square foot of lot area. Most office buildings in San Diego County are more than a half-mile from a trolley stop. The average transaction price per square foot for 143 of these more distant buildings was $28.87. The pattern for retail property transactions during this period — though still indicating a transit accessibility premium — was slightly different. There was no noticeable difference between the sales prices of properties a quarter- to a half-mile from a Trolley stop, and those more distant than a half-mile: both sold at a price of approximately $26 per square foot of lot area. By contrast, retail properties adjacent or very near a Trolley stop (within a quarter-mile) sold at a much higher price per square foot of lot area: $67.12. The same transit-accessibility price gradients were not apparent for industrial uses, auto-oriented uses, or parking uses.

4.3. Alameda, Contra Costa, and San Diego Commercial Property Price Trends: Regression Analysis

Commercial property prices are determined by many more factors than proximity to rail transit. Factors such as building size, age, floor plan, and parking are probably much more significant determinants of commercial property values than proximity to a transit station. Multiple regression allows one to hold constant the effects of these other factors, and thus determine the particular contribution of transit access to property values. For each of the six commercial land-use types identified above, we tested a multiple regression model of the following general form:

1987-93 Commercial Property Sale Price {in 1983 dollars} *(i)*
= f[Building square footage *(i)*,
Lot area *(i)*,
Transaction year dummy variables *(i)*,
City/commercial market dummy variables *(i)*,

Quarter-mile and half-mile transit distance ring dummy variables *(i)*]
where *i* indicates a specific commercial transaction.

Sales prices, lot areas, building areas, sale years, and city locations were extracted from TRW-REDI's on-line data service as noted above. Information on building age, floor plan, and parking availability was unfortunately too spotty to be included. Sale year and city locations were transformed into a series of zero-or-one dummy variables. Two dummy variables were generated to indicate a building's proximity to a BART or San Diego Trolley station, one for a quarter-mile and one for a half-mile. Stepwise regression results are presented separately for commercial land uses in Alameda County (Table 4.2), Contra Costa County (Table 4.3), and San Diego County (Table 4.4). In stepwise regression, variables which are not significant determinants of the value of the dependent variable — in this case, property sales price — do not enter the model.

Table 4.2: Stepwise Regression Results Comparing 1988-1994 Alameda County Commercial Site and Building Transaction Prices by Lot Area, Building Size, Year, City, and Proximity to BART

Dependent Variable: Natural Log of Property Sale Price in 1983 dollars

Independent Variables	All Land Uses	Office Uses	Retail Uses	Industrial Uses	Auto-Uses	Parking Uses	Vacant Land
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Site & Building Variables							
Lot Area	3.15E-07	not entered	4.74E-06	5.82E-06	7.88E-06	2.50E-05	not entered
Building Square Footage	2.47E-07	3.67E-05	3.81E-05	not entered	6.56E-05	not entered	not entered
Transaction Year Dummy Variables							
1988	0.138	0.315	not entered	not entered	not entered	not entered	not entered
1989	not entered	not entered	not entered	not entered	not entered	not entered	not entered
1990	0.22	not entered	not entered	not entered	not entered	not entered	not entered
1991	not entered	not entered	0.27	not entered	not entered	not entered	not entered
1992	not entered	not entered	not entered	not entered	-0.71	not entered	not entered
1993	not entered	not entered	not entered	not entered	not entered	not entered	not entered
City/Market Dummy Variables							
Emeryville	not entered	not entered	0.66	not entered	not entered	not entered	not entered
Fremont	0.35	not entered	0.69	not entered	0.58	not entered	1.08
Livermore	not entered	not entered	not entered	not entered	not entered	not entered	1.20
Oakland	-0.42	-0.32	-0.49	-0.22	not entered	not entered	not entered
Pleasanton	0.85	not entered	not entered	not entered	-1.33	not entered	1.63
Union City	not entered	not entered	not entered	0.83	not entered	not entered	not entered
Bart Proximity Dummy Variables							
within 1/4 mile of BART station	not entered	not entered	not entered	not entered	not entered	not entered	not entered
within 1/2 mile of BART station	not entered	not entered	not entered	not entered	not entered	not entered	0.40
Constant	12.40	12.17	12.13	12.46	12.14	11.661	11.72
Adjusted R -square	0.10	0.43	0.37	0.37	0.58	0.16	0.20
Observations	1430	233	468	394	48	89	185

Table 4.3: Stepwise Regression Results Comparing 1988-1994 Contra Costa County Commercial Site and Building Transaction Prices by Lot Area, Building Size, Year, City, and Proximity to BART

Dependent Variable: Natural Log of Property Sale Price in 1983 dollars (coefficients significant at the .05 level are bolded)

Independent Variables	All Land Uses Coefficient	Office Uses Coefficient	Retail Uses Coefficient	Industrial Uses Coefficient	Auto-Uses Coefficient	Parking Uses Coefficient	Vacant Land Coefficient
Site & Building Variables							
Lot Area	2.33E-07	1.19E-05	1.32E-05	1.39E-06	1.53E-05	does not enter	2.13E-07
Building Square Footage	does not enter	1.27E-05	does not enter	8.96E-06	does not enter	6.35E-05	does not enter
Transaction Year Dummy Variables							
1988	does not enter	does not enter	does not enter	does not enter	1.04	does not enter	does not enter
1989	does not enter	does not enter	does not enter	does not enter	does not enter	does not enter	does not enter
1990	0.23	does not enter	does not enter	0.65	0.62	does not enter	does not enter
1991	does not enter	does not enter	does not enter	does not enter	does not enter	1.06	does not enter
1992	does not enter	does not enter	does not enter	does not enter	-0.73	does not enter	does not enter
1993	-0.33	-0.47	-0.65	does not enter	does not enter	does not enter	does not enter
City/Market Dummy Variables							
Brentwood	does not enter	does not enter	does not enter	-0.55	does not enter	does not enter	does not enter
Concord	0.54	0.34	does not enter	0.43	does not enter	does not enter	does not enter
Danville	0.45	does not enter	does not enter	does not enter	does not enter	does not enter	0.63
Lafayette	does not enter	0.83	does not enter	does not enter	does not enter	does not enter	does not enter
Pittsburg	does not enter	-0.70	does not enter	does not enter	does not enter	does not enter	does not enter
Richmond	-0.33	does not enter	-0.54	-0.50	does not enter	does not enter	does not enter
San Pablo	does not enter	does not enter	-0.45	does not enter	does not enter	does not enter	does not enter
San Ramon	0.74	0.73	does not enter	does not enter	does not enter	does not enter	does not enter
Walnut Creek	0.53	0.63	0.72	1.26	does not enter	-1.16	does not enter
Bart Proximity Dummy Variables							
within 1/4 mile of BART station	does not enter	does not enter	does not enter	does not enter	does not enter	does not enter	does not enter
within 1/2 mile of BART station	does not enter	does not enter	does not enter	does not enter	does not enter	does not enter	does not enter
Constant	12.28	11.87	12.16	12.32	11.87	11.83	12.11
Adjusted R -square	0.13	0.43	0.39	0.57	0.54	0.34	0.14
Observations	836	170	179	115	44	42	272

Table 4.4: Stepwise Regression Results Comparing 1988-1994 San Diego County Commercial Site and Building Transaction Prices by Lot Area, Building Size, Year, City, and Proximity to San Diego Trolley

Dependent Variable: Natural Log of Property Sale Price in 1983 dollars

Independent Variables	All Land Uses	Office Uses	Retail Uses	Industrial Uses	Auto-Uses	Parking Uses	Vacant Land
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Site & Building Variables							
Lot Area	2.67E-08	3.21E-06	4.40E-06	2.70E-06	1.80E-05	5.29E-06	2.95E-08
Building Square	3.30E-05	1.91E-05	2.00E-05	2.32E-05	not entered	9.78E-05	not entered
Transaction Year Dummy Variables							
1988	0.32	not entered	0.30	0.51	0.50	not entered	not entered
1989	0.24	not entered	0.24	0.33	not entered	not entered	not entered
1990	0.23	not entered	0.30	0.30	not entered	not entered	not entered
1991	0.17	not entered	not entered	not entered	not entered	not entered	not entered
1992	not entered	-0.42	not entered	not entered	not entered	not entered	not entered
1993	not entered	not entered	not entered	-0.35	not entered	not entered	-0.18
City/Market Dummy Variables							
Alpine	-0.32	not entered	not entered	not entered	not entered	not entered	not entered
Boulevard	-0.65	not entered	-2.74	not entered	not entered	not entered	-0.40
Carlsbad	0.90	not entered	not entered	not entered	not entered	not entered	1.04
Chula Vista	0.52	not entered	not entered	not entered	not entered	not entered	not entered
El Cajon	not entered	-0.73	not entered	not entered	not entered	not entered	not entered
Escondido	not entered	not entered	not entered	-0.44	not entered	not entered	not entered
Fallbrook	-0.31	not entered	not entered	not entered	not entered	not entered	not entered
Jamul	-0.53	not entered	not entered	not entered	not entered	not entered	-0.25
Julian	-0.31	not entered	not entered	not entered	not entered	not entered	not entered
Oceanside	0.56	-0.82	not entered	not entered	not entered	not entered	1.43
Ramona	-0.30	not entered	-0.79	not entered	not entered	not entered	not entered
San Diego	0.39	not entered	not entered	not entered	not entered	not entered	0.39
San Marcos	0.50	not entered	0.49	-0.34	not entered	not entered	0.68
San Ysidro	0.39	not entered	not entered	not entered	not entered	not entered	0.56
Valley Center	not entered	not entered	not entered	not entered	not entered	not entered	0.23
Vista	0.41	not entered	not entered	not entered	not entered	not entered	0.68
San Diego Trolley Proximity Dummy Variables							
within 1/4 mile of Trolley station	not entered	not entered	not entered	not entered	not entered	not entered	not entered
within 1/2 mile of Trolley station	not entered	not entered	-0.22	-0.46	not entered	not entered	not entered
Constant	11.66	12.24	12.09	12.41	12.11	11.82	11.55
Adjusted R -square	0.34	0.36	0.39	0.59	0.52	0.27	0.14
Observations	2968	216	614	313	60	67	1662

Alameda County Commercial Property Sales: None of the various regression models presented in Table 4.2 explain Alameda County commercial property prices particularly well. The model of auto-oriented land uses performs best, explaining 58 percent of the variation in property sales prices. The worst-performing model is the parking uses model, in which only 16 percent of the variation in sales prices is explained by the various independent variables. Lot area and building square footage are of the expected sign and generally statistically significant. After accounting for city location, the only property type for which proximity to BART is statistically significant is *vacant land*. Controlling for building size, lot area, transaction year, and city, proximity to BART was not a significant determinant of sales prices for Alameda County office buildings, retail buildings, industrial buildings, auto-oriented uses, or parking lots.

Contra Costa County Commercial Property Sales: The regression results presented in Table 4.3 confirm the ANOVA results presented above: controlling for different building sizes, lot sizes, and locations, commercial properties close to BART stations in Contra Costa County did not sell at a premium between 1988 and 1994. The various regression models explain 1988-94 commercial sales prices in Contra Costa County about as well as they explain commercial sales prices in Alameda County. In Contra Costa County, as in Alameda County, lot area, building size, and city are the key determinants of commercial sales prices, not BART access.

San Diego County Commercial Property Sales: Lot area and building square footage were even more important determinants of office, retail, and industrial property sales prices in San Diego County than in Alameda or Contra Costa counties. After accounting for those two factors, as well as market area and transaction year, proximity to a San Diego Trolley stop did not enter the various stepwise models on a consistent basis. Moreover, in the two cases where transit proximity did enter the models — for retail and industrial uses within a quarter- to a half-mile of a Trolley stop — the coefficient estimate was unexpectedly negative. This suggests that constant quality industrial and retail properties near Trolley stops sell at a discount when compared with similar, more distant properties. Given the poor overall "fit" of these models (ranging from .14 for vacant land to .59 for industrial uses), this latter finding should be viewed with caution.

4.4. Summary and Caveats

Summary

Are commercial property prices higher near BART and San Diego Trolley stations than at more distant locations? The answer to this question is, *it depends* — on the specific land use, on the area and property market, and on the way in which property prices are measured. In Alameda County, for example, office, retail, and industrial properties located near BART stations *sold at a premium* — when measured on the basis of price-per-square-foot of lot area. Measured the same way, office and retail uses in San Diego County located near Trolley stops also sold at a premium. In Contra Costa County, by contrast, commercial properties located near BART station *did not sell* at a premium. Indeed, depending on the property type, some sold at a discount.

Measured in a different way — using regression analysis to account for differences in lot size, building size, and market area — the transit premiums disappear. Measured in "constant-quality terms," Alameda and San Diego County office, retail, and industrial properties near BART and Trolley stations *did not sell at a premium* compared to more distant, but otherwise similar buildings. The ambiguity in these results is due to the fact that commercial properties near BART and San Diego Trolley stations tend to be bigger, newer, and better than properties *not* near transit stations. Statistically, the problem becomes one of correctly apportioning price differentials into a "quality" component and a "transit accessibility" component. In fact, the two components are most likely related. In response to perceived market preferences and/or to public regulation, commercial developers have in fact built higher-quality office, retail, and industrial properties near transit stations than elsewhere.

Caveats

We offer two caveats to these findings. The first is that because so much information regarding property characteristics is unknown or unavailable, the ANOVA and regression models are necessarily incomplete. Were additional information on property characteristics to become available, it might be possible to more definitively estimate the commercial property sale value of accessibility to BART and the San Diego Trolley. A second caveat concerns data coverage. Even though we collected sales data covering a seven-year period, the number of sales observations is quite small — particularly for auto-oriented uses and parking lots. Given more property sales, and, in particular, given more property sales near BART and San Diego Trolley stations, it is conceivable that the various models might produce different results.

CHAPTER FIVE:
Rail Transit Investments and Station Area Land-Use Changes: 1965-1990

by John Landis and Ming Zhang, with Bruce Fukuji and Sourev Sen

If investments in rail transit facilities *do* impact land uses, those impacts are likely to be most visible at or near transit stations. This chapter examines the determinants of land-use changes at nine BART stations and four San Diego Trolley Stations. Using maps and statistical techniques, we seek to determine whether sites near BART and San Diego Trolley stations developed earlier, or in different uses than more distant sites. The nine BART and four San Diego Trolley stations upon which this analysis is based include:

BART Stations	San Diego Trolley Stations
Concord	Amaya
Daly City	El Cajon
El Cerrito del Norte	Palm
Fremont	Spring
Hayward	
Pleasant Hill	
Rockridge	
Union City	
Walnut Creek	

Three criteria were used to select these 13 stations. The first was *data availability*; specifically, it was essential that historical information on station area land uses be available. The second was *change*: we had to be able to observe some level of land-use change at or near the stations during the study period. A third criterion was that the selected stations be broadly representative of all BART and San Diego Trolley station types.

This analysis spans several different time periods. Land-use changes at BART stations are examined over two periods, 1965-1975, the years during which the system was under construction; and 1975-90, the first 15 years of (full) system operation. Our analysis of land-use change around San Diego Trolley stations spans the years 1980-1994 for stations along the North-South line, and 1985-1994 for stations along the East-West line. Section 5.1 describes land-use patterns near each station at the beginning and end of their respective study periods. Section 5.2 builds on the descriptive analysis to specify a series of statistical models of land-use change. Known as *logit* models, these models examine the relationships between proximity to a BART or San Diego Trolley station, and land-use change. Sections 5.3 and 5.4 present the results of the various models, and Section 5.5 discusses the implications and limitations of those results.

5.1. Land-Use Changes at Selected BART and San Diego Trolley Stations

Is there a typical land-use pattern around rail transit stations? And how, if at all, does the construction of a transit station affect nearby land-use patterns? This part describes the changing mix of land uses at nine BART stations in 1965, 1975, and 1990; and at four San Diego Trolley stations between 1980 and 1994.

Building Maps of Land-Use Change

The first task in any analysis of land-use change is to assemble a basemap. This is easier said than done, particularly when one wishes to examine changes in land use over time. Cities typically maintain *current* zoning maps (which delimit permitted uses) and parcel maps (which indicate parcel boundaries), but not maps of current land uses. Nor do transit districts such as BART or the San Diego Trolley typically maintain maps of land uses near their stations.

The only comprehensive land-Use basemap presently available in California is published in digital form by the Association of Bay Area Governments (ABAG). The ABAG basemap covers the entire nine-county San Francisco Bay Area and is composed of hectare grid-cells (100m x 100m), coded by dominant land use. First developed in 1985, ABAG's map was updated in 1990. Using a geographic information system, we "clipped-out" all of the hectare grid-cells within one-half mile of a BART station, along with their dominant 1990 land uses.

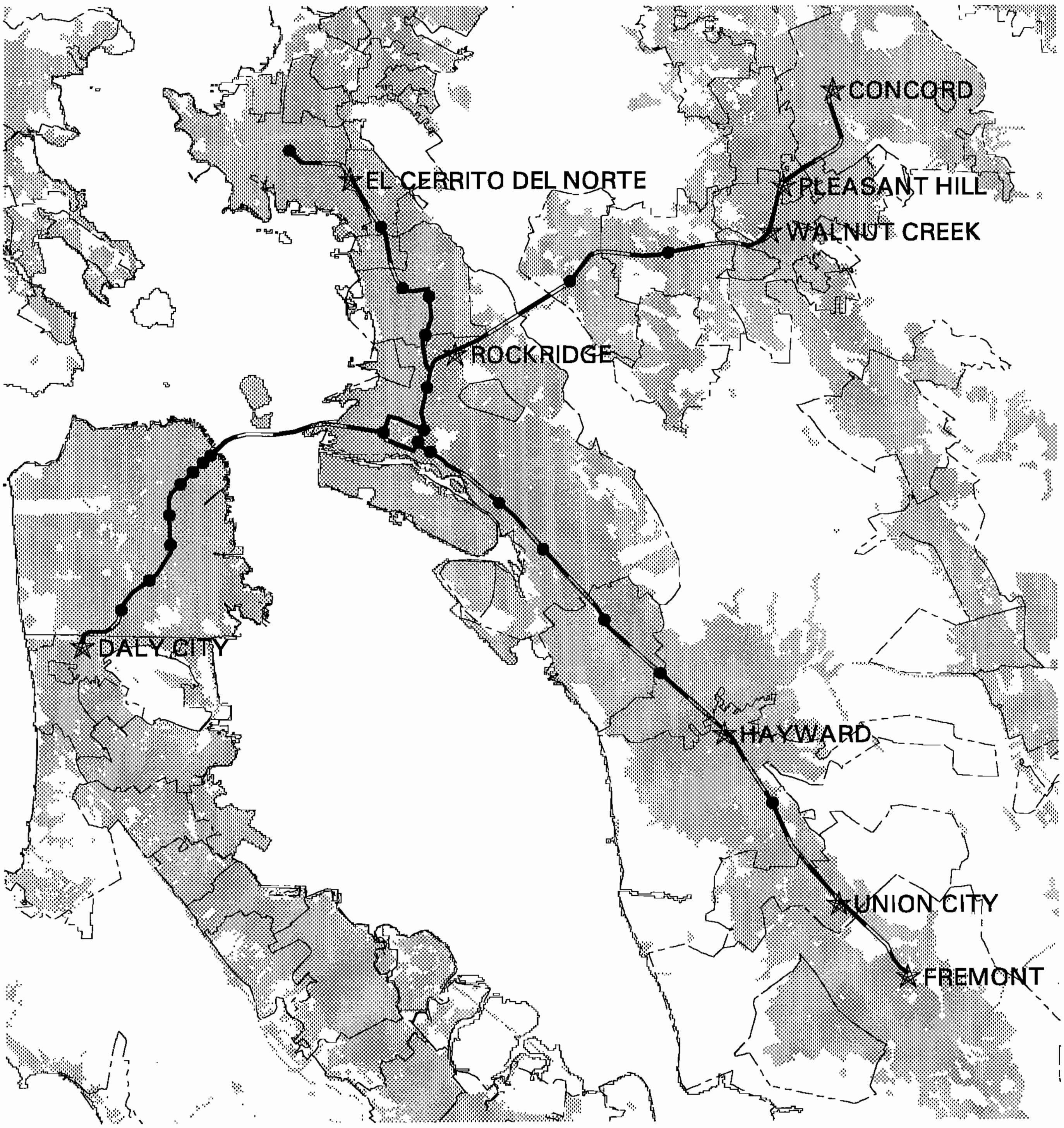
Pre-BART land-use data was generated by overlaying the ABAG hectare grid-system on 1965[17] and 1975 station area aerial photographs, and then assigning dominant land uses based on discernible uses and patterns. Seven land uses were assigned: (i) undeveloped or vacant; (ii) single-family residential; (iii) attached residential; (iv) commercial (office/retail); (v) industrial; (vi) institutional (schools, public buildings, and parks); and (vii) transportation (highways, transit lines, and parking lots). The 1965, 1975, and 1990 inventories were then cross-checked against each other for inconsistencies and errors. A similar method was used to identify land-use changes near San Diego Trolley stations. Aerial photographs of Trolley station areas for 1980 and 1994 were obtained, gridded into hectare grid-cells, and then coded according to dominant land use. All of these operations were undertaken digitally using a geographic information system.

The use of hectare grid-cells to map land-use changes has both advantages and disadvantages. On the positive side, hectare grid-cells are large enough to capture broad land-use changes, but small enough so as not to over-generalize those changes. On the negative side, at 100m by 100m, hectare grid-cells are too large to identify land uses at particular parcel locations.

Land-Use Patterns and Changes Near Nine BART Stations: 1965-1990

The nine BART stations included in this analysis are extremely diverse (Map 5.1). They include three of the four end-of-the-line stations (Concord, Daly City, and Fremont), four stations on the Rich-

Map 5.1: BART Stations Selected



mond-Fremont line (El Cerrito Del Norte, Fremont, Union City, and Hayward), and five stations on the Concord Daly City Line (Pleasant Hill, Rockridge, Daly City, Concord, and Walnut Creek). Three of the stations (El Cerrito Del Norte, Rockridge, and Daly City) were constructed in built-out urban areas, so subsequent land-use changes have predominantly taken the form of *re-development*. The other six stations (Fremont, Union City, Pleasant Hill, Walnut Creek, Concord, and Pleasant Hill) were constructed in areas with considerable *new* development potential . All nine stations are surrounded by sizeable parking areas.

Summed over all nine stations, residential development was the largest single dominant land use in 1965 (46.9 percent), followed by vacant or undeveloped (27.6 percent), and commercial development (14.5 percent). Roads and highways, and public uses each comprised 4.2 percent of station area land uses in 1965. Industrial uses accounted for the remaining 2.1 percent of the land uses. Appendix B includes summary maps of dominant land uses at each of the nine BART stations for 1965, 1975, and 1990.

Twenty-five years later — by 1990 — although there had been significant development, the overall pattern of land uses had changed only slightly (Figure 5.1). The biggest single change, of course, was the reduction in vacant and developed land: as of 1990, only 4.2 percent of land uses within a half-mile of the nine BART stations was either vacant or undeveloped — down from 27.6 percent in 1965. Of the nine station areas, only Fremont station included significant amounts of vacant land or open space as of 1990.

Altogether, 1,557 acres of land area classified as vacant or undeveloped in 1965 were developed by 1990. Of this total, 41 percent were converted to residential uses, 21 percent to commercial uses, 16 percent to public uses, and 15 percent to industrial uses; 7 percent were developed as roads, transit right-of-way, or parking lots. Most of these changes occurred between 1975 and 1990.

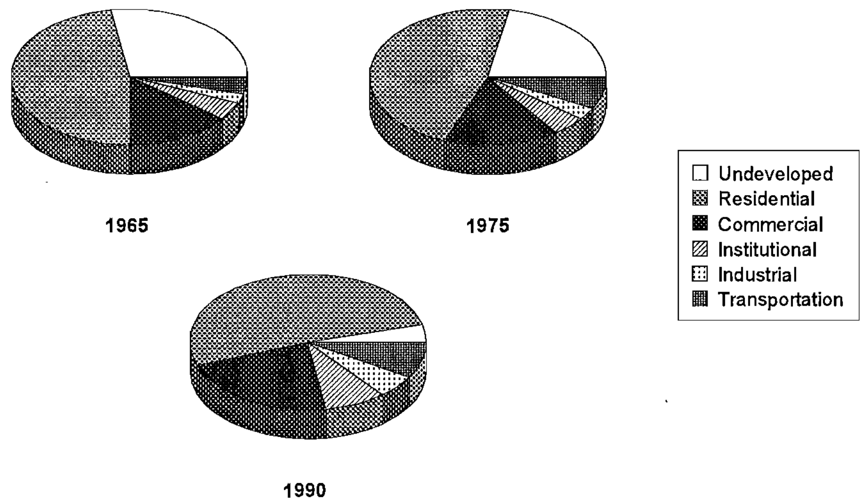
Vacant land was not the only land type near BART stations to be developed. Between 1965 and 1990, 344 acres of *residential* land near the nine BART stations were converted to other uses. Commercial development accounted for the biggest single share of residential redevelopment (44 percent), followed by the construction of transportation facilities — mostly BART parking lots (37 percent).

Changes to other types of land uses were minor. Altogether, only 92 acres of non-residential uses in 1965 were redeveloped into other uses by 1965. In sum, of the 6,210 acres of land area within a half-mile radius of the nine BART stations, a significant amount — nearly a third — changed land uses between 1965 and 1990.

The result of these changes was a subtle, though significant shift in the pattern of land uses around the nine stations (Table 5.1 and Figure 5.2):

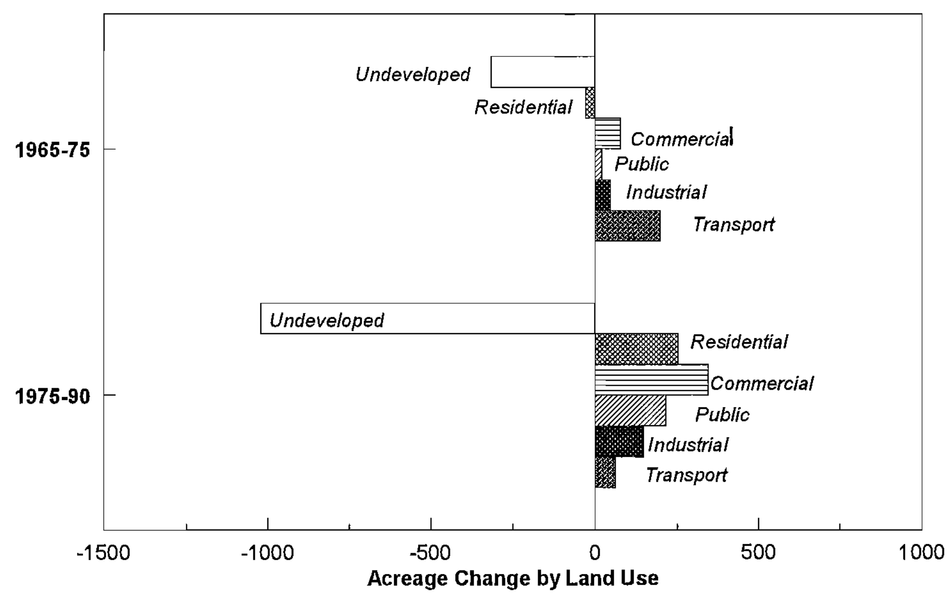
- Residential uses increased from 47.4 percent of station area land uses in 1965, to 51.3 percent in 1990. Most of this gain occurred during the 1975-90 period. The station areas with the largest gains in residential land uses between 1965 and 1990 were Fremont, Union City, and Walnut Creek. At the Rockridge station, the share of land in residential use declined significantly during this period — primarily through the demolition of older homes to make way for BART parking lots.

Figure 5.1a: Dominant Land Use Shares at Nine* BART Stations: 1965, 1975, and 1990



* includes El Cerrito Del Norte, Fremont, Union City, Pleasant Hill, Daly City, Rockridge, Walnut Creek, Concord, and Hayward

Figure 5.1b: Land Use Changes at Nine* BART Stations: 1965-75 and 1975-90



* includes El Cerrito Del Norte, Fremont, Union City, Pleasant Hill, Daly City, Rockridge, Walnut Creek, Concord, and Hayward

Table 5.1: 1965, 1975, and 1990 Distribution of Dominant Land Uses at Nine BART Station Areas

		Land Use Distribution by Category and Year						
Station Area		Vacant	Residential	Commercial	Public	Industrial	Transportation	Total
Daly City	1965	10.9%	55.7%	10.4%	4.1%	0.0%	19.0%	1,349
	1975	10.9%	52.0%	10.9%	4.1%	0.0%	22.2%	1,349
	1990	0.9%	55.2%	14.0%	4.1%	0.0%	25.8%	1,349
	Acreage Change: 1965-75	0	-20	2	0	0	17	0
	Acreage Change: 1975-90	-54	17	17	0	0	20	0
Fremont	1965	85.1%	6.0%	6.3%	2.6%	0.0%	0.0%	1,844
	1975	71.5%	11.9%	10.6%	4.3%	0.0%	1.7%	1,844
	1990	31.1%	33.4%	21.9%	11.9%	0.0%	1.7%	1,844
	Acreage Change: 1965-75	-101	44	32	12	0	12	
	Acreage Change: 1975-90	-301	161	84	57	0	0	
Pleasant Hill	1965	7.6%	76.5%	10.0%	0.0%	0.0%	6.0%	1,533
	1975	3.2%	73.7%	12.4%	0.0%	0.0%	10.8%	1,533
	1990	0.0%	72.9%	15.5%	0.0%	0.0%	11.6%	1,533
	Acreage Change: 1965-75	-27	-17	15	0	0	30	
	Acreage Change: 1975-90	-20	-5	20	0	0	5	
Union City	1965	64.6%	14.4%	0.0%	8.0%	12.9%	0.0%	1,606
	1975	45.6%	18.3%	1.1%	9.5%	22.1%	3.4%	1,606
	1990	0.0%	25.9%	9.5%	13.3%	47.9%	3.4%	1,606
	Acreage Change: 1965-75	-124	25	7	10	59	22	
	Acreage Change: 1975-90	-297	49	54	25	168	0	
Hayward	1965	10.2%	40.3%	38.1%	0.9%	5.8%	4.9%	1,380
	1975	10.2%	39.8%	37.6%	0.9%	4.0%	7.5%	1,380
	1990	0.4%	42.5%	42.5%	5.8%	0.9%	8.0%	1,380
	Acreage Change: 1965-75	0	-2	-2	0	-10	15	
	Acreage Change: 1975-90	-54	15	27	27	-17	2	
Rockridge	1965	1.5%	81.4%	9.5%	6.5%	0.0%	1.1%	1,606
	1975	1.9%	75.7%	9.5%	6.5%	0.0%	6.5%	1,606
	1990	0.0%	72.6%	13.3%	7.2%	0.0%	6.8%	1,606
	Acreage Change: 1965-75	2	-37	0	0	0	35	
	Acreage Change: 1975-90	-12	-20	25	5	0	2	
Walnut Creek	1965	44.3%	25.6%	21.5%	4.1%	0.4%	4.1%	1,502
	1975	34.1%	27.6%	26.8%	3.7%	0.4%	7.3%	1,502
	1990	0.0%	34.6%	39.0%	15.0%	0.0%	11.4%	1,502
	Acreage Change: 1965-75	-62	12	32	-2	0	20	
	Acreage Change: 1975-90	-208	42	74	69	-2	25	
Concord	1965	5.6%	66.4%	21.3%	5.9%	0.0%	0.7%	1,746
	1975	5.2%	62.9%	20.6%	5.9%	0.0%	5.2%	1,746
	1990	0.0%	61.2%	25.2%	8.4%	0.0%	5.2%	1,746
	Acreage Change: 1965-75	-2	-25	-5	0	0	32	
	Acreage Change: 1975-90	-37	-12	32	17	0	0	
El Cerrito del Norte	1965	6.7%	65.9%	16.9%	5.1%	0.0%	5.5%	1,557
	1975	6.3%	64.3%	16.1%	5.5%	0.0%	7.8%	1,557
	1990	0.0%	65.1%	18.0%	7.8%	0.0%	9.0%	1,557
	Acreage Change: 1965-75	-2	-10	-5	2	0	15	
	Acreage Change: 1975-90	-40	5	12	15	0	7	
Total	1965	27.6%	47.4%	14.5%	4.2%	2.1%	4.2%	14,123
	1975	22.1%	46.9%	15.8%	4.6%	2.9%	7.7%	14,123
	1990	4.2%	51.3%	21.9%	8.3%	5.5%	8.7%	14,123
	Acreage Change: 1965-75	-316	-30	77	22	49	198	
	Acreage Change: 1975-90	-1023	252	346	215	148	62	

Figure 5.2a: Land Use Changes at the Concord BART Station: 1965-75 and 1975-90

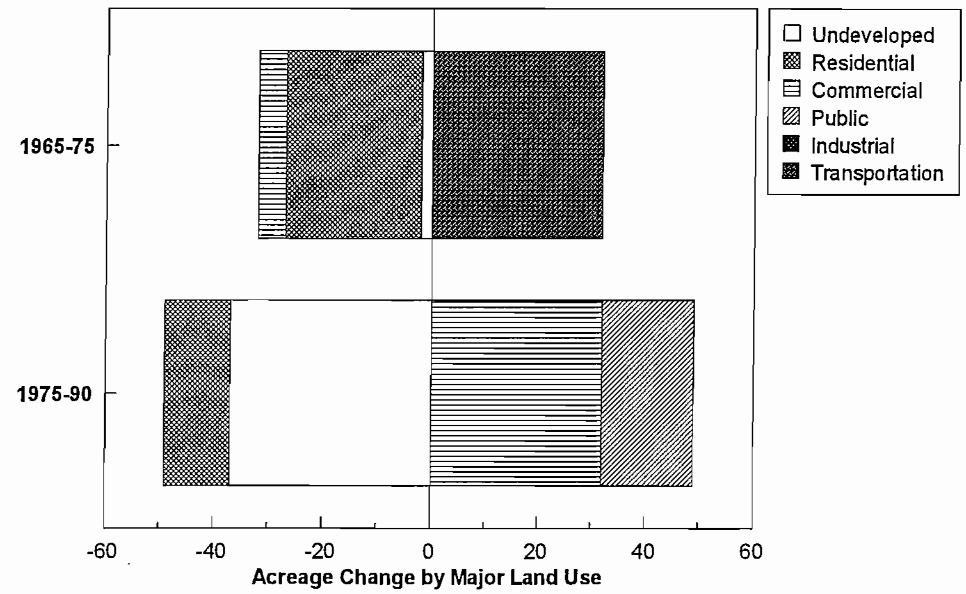


Figure 5.2b: Land Use Changes at the Daly City BART Station: 1965-75 and 1975-90

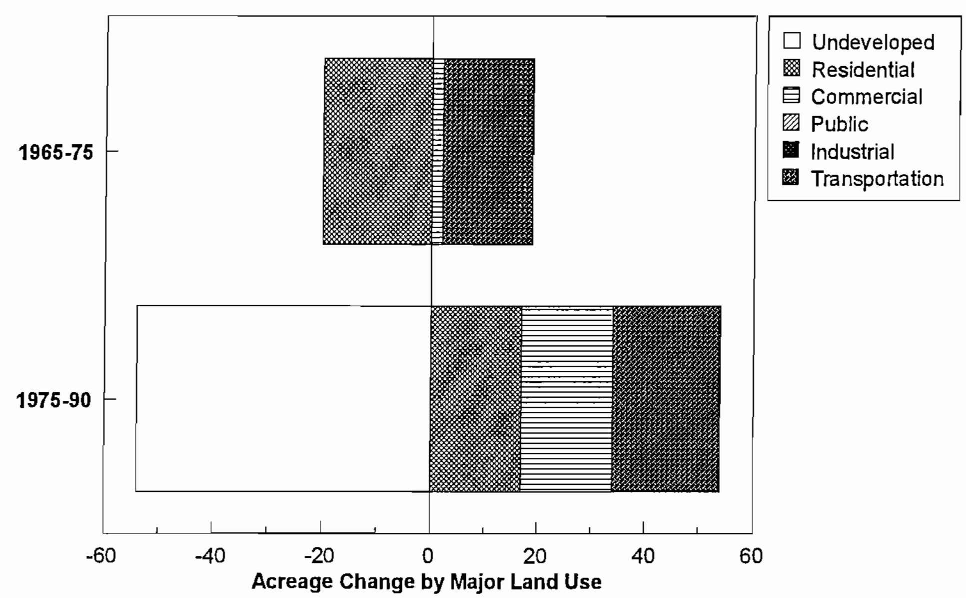


Figure 5.2c: and Use Changes at the El Cerrito del Norte BART Station: 1965-75 and 1975-90

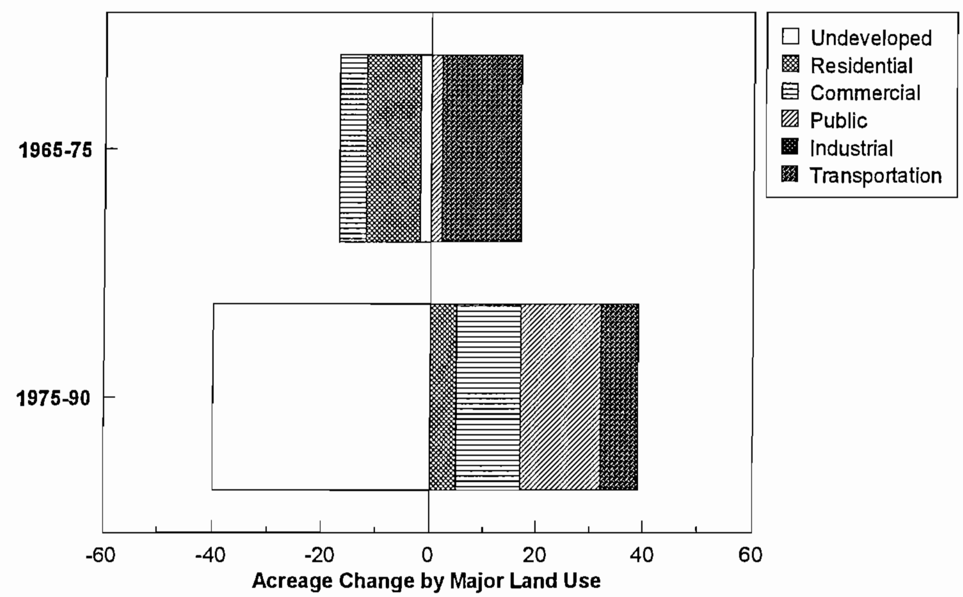


Figure 5.2d: Land Use Changes at the Fremont BART Station: 1965-75 and 1975-90

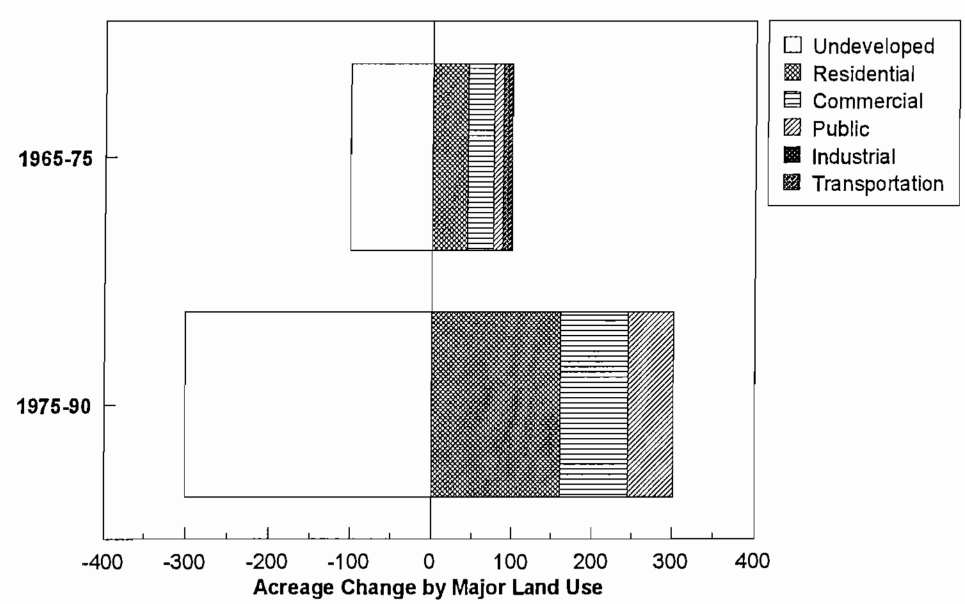


Figure 5.2e: Land Use Changes at the Hayward BART Station: 1965-75 and 1975-90

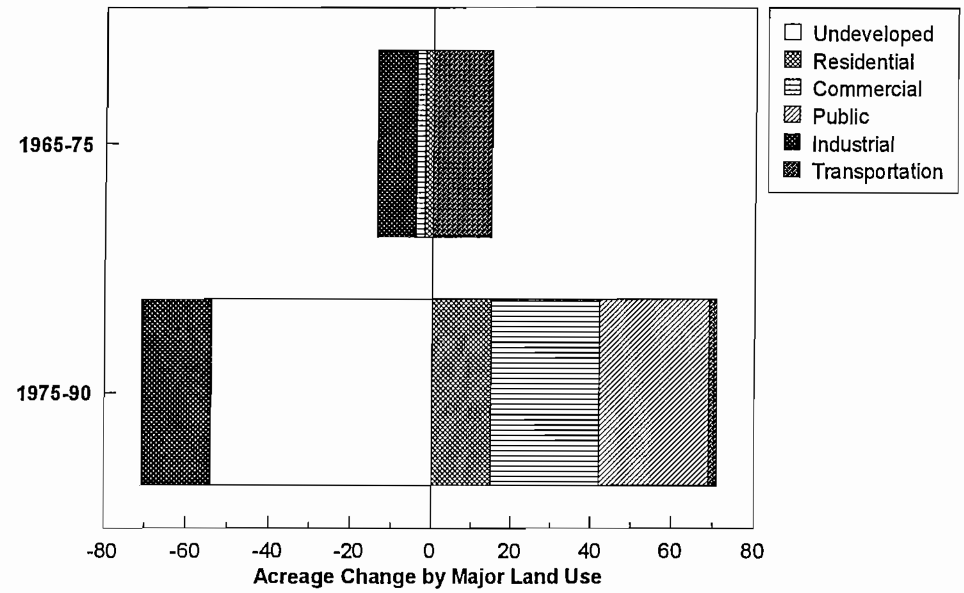


Figure 5.2f: Land Use Changes at the Pleasant Hill BART Station: 1965-75 and 1975-90

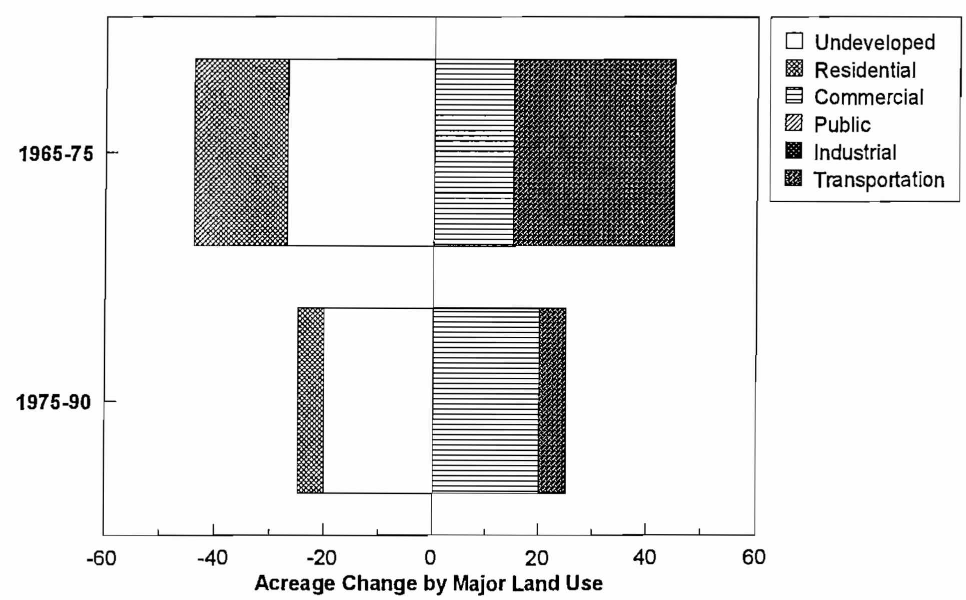


Figure 5.2g:Land Use Changes at the Rockridge BART Station: 1965-75 and 1975-90

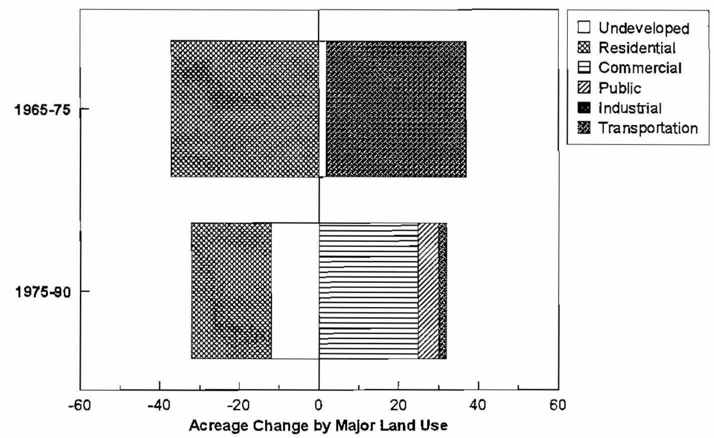


Figure 5.2h: Land Use Changes at the Union City BART Station: 1965-75 and 1975-90

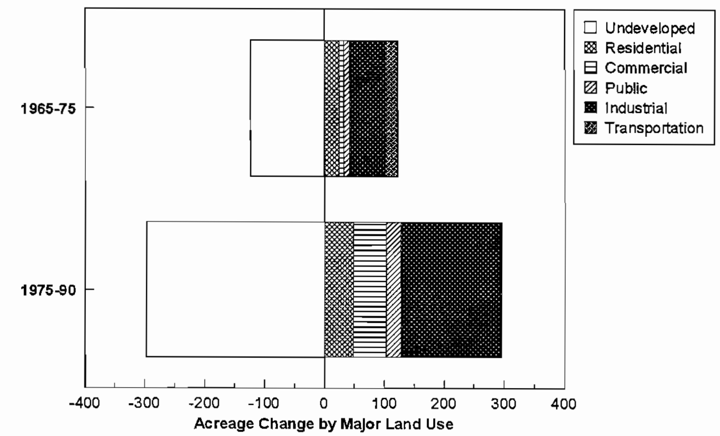
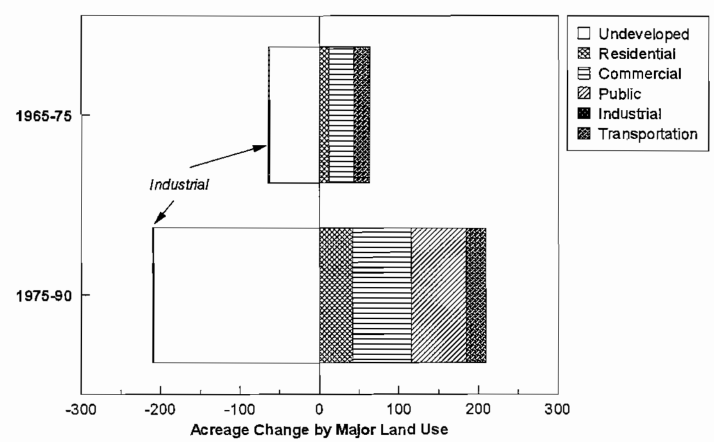


Figure 5.2i: Land Use Changes at the Walnut Creek BART Station: 1965-75 and 1975-90



- Commercial (Retail and Office) land uses increased from 14.5 percent of station area land uses in 1965, to 21.9 percent in 1990. Although increased commercial development occurred at all nine station areas during this period, it was most focused at the Fremont and Walnut Creek stations.
- Institutional land uses (including schools, parks and play fields, and city buildings) increased from 4.2 percent of station area land uses in 1965, to 8.3 percent in 1990. Increases in institutional land uses were focused at the El Cerrito, Fremont, Union City, Walnut Creek, and Hayward stations.
- Industrial land uses increased from 2.1 percent of station area land uses in 1965 to 5.5 percent in 1990. Almost all of this increase occurred at the Union City station.
- The increase in transportation-related land uses (from 4.2 percent in 1965, to 8.3 percent in 1990) was entirely due to construction of BART parking facilities.

A closer look at the nine BART stations suggest that they can be categorized into two broad groups. The first group consists of station areas in which the current pattern of land uses was determined between 1965 and 1990, concurrently with the development of BART. This group includes Fremont, Union City, and Walnut Creek. In 1965, all three of these stations were surrounded by large tracts of vacant or undeveloped land. Almost all of this land was subsequently developed. In Walnut Creek, it was developed as a mixture of residential, commercial, and public uses. In Union City, the development mix favored industrial uses. In Fremont, it favored residential and commercial uses. There is one other commonality among these three stations: a significant amount of the new development which occurred around them between 1965 and 1990 took the form of public and institutional uses.

The second group of six station areas included far less amounts of vacant land in 1965, and experienced considerably less new development between 1965 and 1990. Except for the Hayward station, the 1990 land-use mix at these six station areas was dominated by residential uses — just as it had been in 1965. Despite their relative stability, five of the six areas experienced a slight tilt away from residential land uses and towards higher-order commercial uses. Only one — Daly City — experienced an increase in residential land-use share between 1965 and 1990.

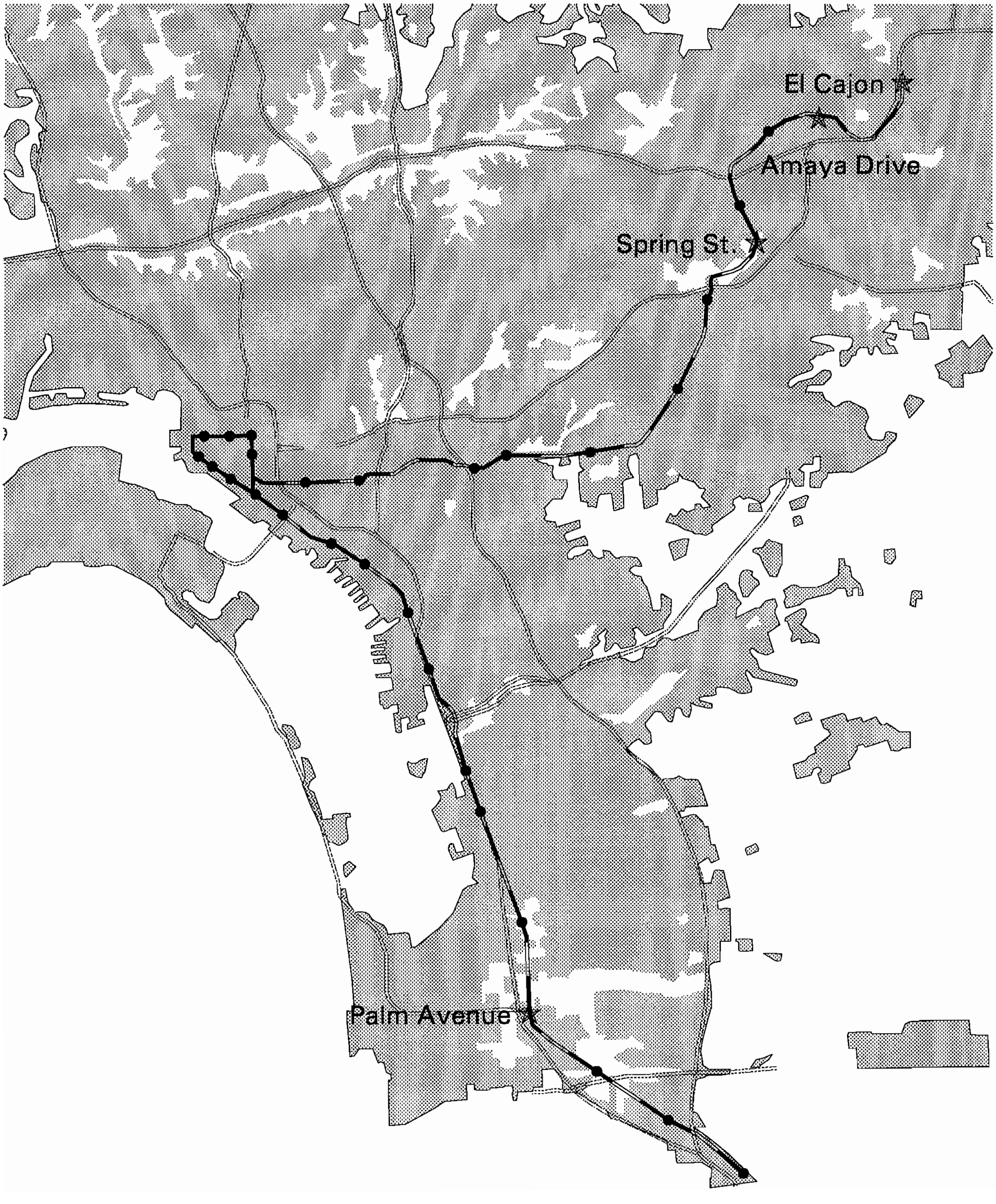
Land-Use Patterns and Changes Near Four San Diego Trolley Stations: 1985-1994

Three of the four San Diego Trolley stations included in this analysis (Amaya, Spring Street, and El Cajon) are on the East-West line; the fourth, Palm Street, is on the North-South Line (Map 5.2). The newer East-West line extends eastward into several older suburban communities. The older North-South runs along an old railroad right-of-way through existing industrial areas.

Summed over all four stations, single-family residential development was the largest single dominant land use in 1985 (40.8 percent), followed by vacant or undeveloped land (19.7 percent), commercial development (10.9 percent), and roads, highways, and railroads (10.5 percent). Appendix C includes summary maps of dominant land uses at each of the four Trolley stations for 1985 and 1994.

Nine years later, although there had been significant development near the four stations, the overall pattern of land uses had changed only slightly (Figures 5.3 and 5.4):

Map 5.2: San Diego Trolley Stations Selected



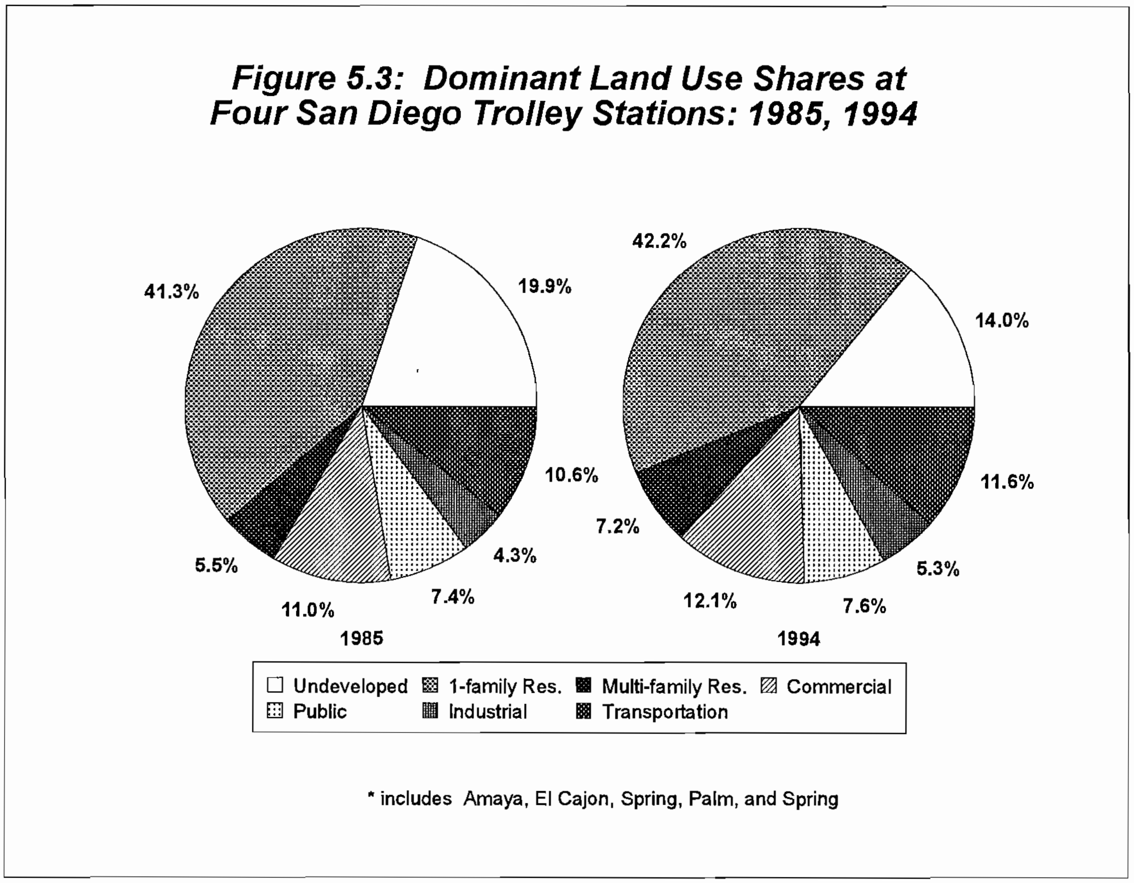


Figure 5.3: Dominant Land Use Shares at Four San Diego Trolley Stations: 1985, 1994
41.3%
19.9%
10.6%
4.3%
7.4%
11.0%
5.5%
1985
42.2%
14.0%
11.6%
5.3%
7.6%
12.1%
7.2%
1994
Undeveloped
1-family Res.
Multi-family Res.
Commercial
Public
Industrial
Transportation
* includes Amaya, El Cajon, Spring, Palm, and Spring

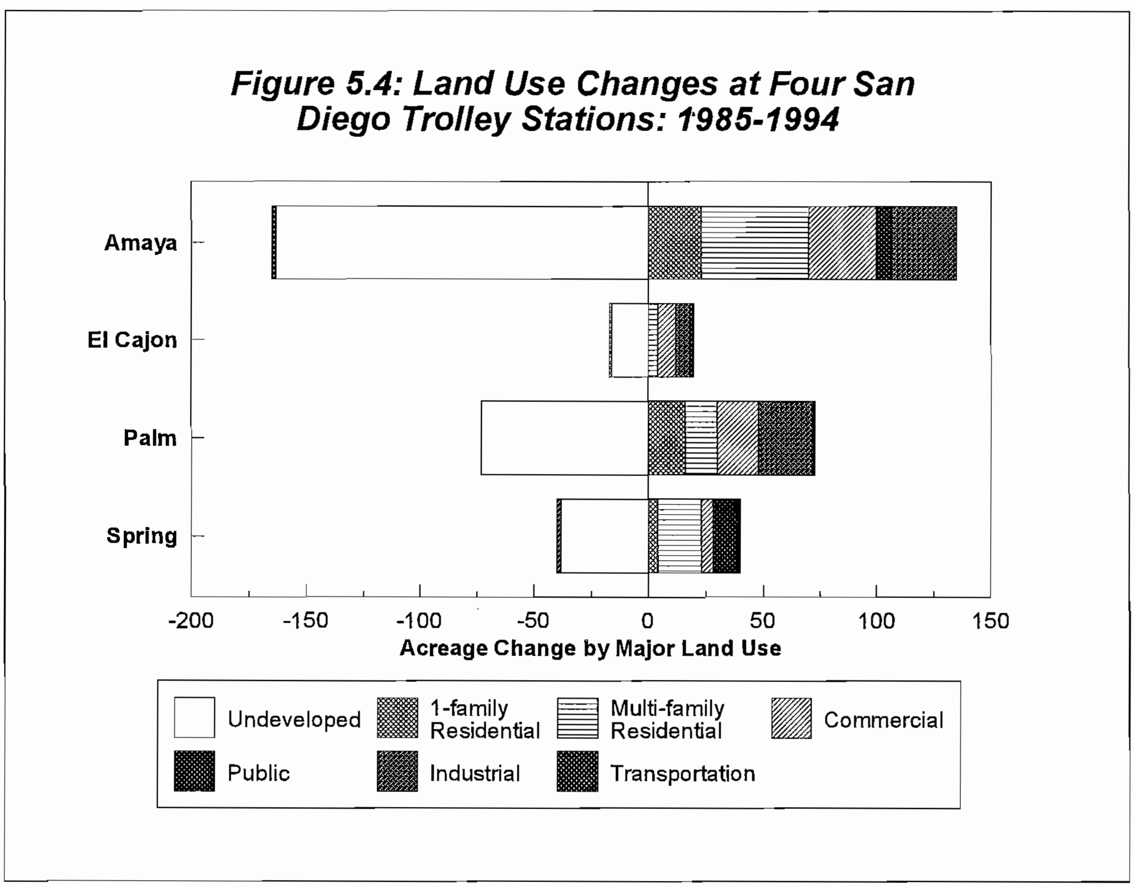


Figure 5.4: Land Use Changes at Four San Diego Trolley Stations: 1985-1994
Amaya
El Cajon
Palm
Spring
-200
-150
-100
-50
0
50
100
150
Acreage Change by Major Land Use
Undeveloped
1-family Residential
Multi-family Residential
Commercial
Public
Industrial
Transportation

- The single biggest change, of course, was the reduction in undeveloped land supplies: as of 1994, only 13.8 percent of the land area within a half-mile of the four transit stations was undeveloped — down from 19.7 percent in 1985. Altogether, 163 acres of land classified as vacant or undeveloped in 1985 were developed by 1994.
- Single-family residential uses increased only slightly, from 40.8 percent of station area land uses in 1985, to 41.7 percent in 1994. Almost all of this gain was at the Palm Street station.
- Multi-family residential uses increased from only 5.4 percent of station area land uses in 1985, to just over 7 percent in 1994. This gain was divided across three stations: Palm, Spring, and Amaya.
- Commercial (Retail and Office) land uses increased from 10.9 percent of station area land uses in 1985 to 12 percent in 1994. As with single-family development, most of this gain was concentrated at the Palm Street Station.
- Public and institutional land uses (including schools, parks and play fields, and city buildings) increased only marginally, from 7.3 percent of station area land uses in 1985, to 7.5 percent in 1994. All of this gain was at the Spring Street station.
- Industrial land uses increased from 4.2 percent of station area land uses in 1985 to 5.2 percent in 1994. Almost all of this increase occurred at the Palm Street Station.
- The increase in transportation-related land uses (from 10.5 percent in 1985, to 11.5 percent in 1994) was mostly due to construction of Trolley right-of-way and parking facilities.

Nor was there much change in land-use patterns at any of the four stations: (Table 5.2):

- The strongly residential character of the Amaya and Spring Street Trolley stations was bolstered by small amounts of new single- and multi-family residential development.

Table 5.2: 1985 and 1994 Distribution of Dominant Land Uses at Four San Diego Trolley Station Areas

		Land Use Distribution by Category and Year							
Station Area		Vacant	Single-Family	Multi-Family	Com-mercial	Public	Indus-trial	Trans-portation	Total
El Cajon	1985	9.8%	38.4%	11.5%	18.8%	4.2%	7.7%	9.3%	662
	1994	7.4%	38.3%	12.1%	20.0%	4.2%	8.6%	9.3%	662
	Acreage Change:	-16	-1	4	8	0	6	-2	
Palm	1985	43.6%	17.7%	5.5%	2.5%	6.0%	7.7%	12.4%	695*
	1994	33.6%	19.9%	7.4%	4.9%	6.0%	11.0%	12.5%	695*
	Acreage Change:	-73	16	14	18	0	24	1	
Spring	1985	11.0%	49.1%	2.1%	12.3%	11.9%	1.5%	12.2%	682
	1994	5.4%	49.7%	4.8%	13.1%	13.5%	1.2%	12.3%	682
	Acreage Change:	-38	4	19	5	11	-2	1	
Amaya	1985	12.6%	59.0%	2.8%	10.7%	6.9%	0.0%	7.9%	707
	1994	7.5%	59.5%	4.2%	10.6%	6.4%	0.0%	11.7%	707
	Acreage Change:	-36	4	10	-1	-4	0	27	
4-Station Total	1985	19.7%	40.8%	5.4%	10.9%	7.3%	4.2%	10.5%	2,782
	1994	13.8%	41.7%	7.1%	12.0%	7.5%	5.2%	11.5%	2,782
	Acreage Change:	-163	23	47	30	7	28	30	

***Notes**: * excludes mobile home uses*

- Vacant land near the El Cajon station was developed with almost exactly the same proportion of developed land uses as existed near the station in 1985.
- Although there was substantial new development at the Palm Street Station, it favored no single land-use type: The shares of single-family residential, multi-family residential, commercial, and industrial land uses each increased by about two percent.

5.2. Modeling Land-Use Changes Near Transit Stations

Land-use changes are simple to observe but hard to model or explain. They are simple to observe because they are discrete. Through the process of development, individual parcels or sites change from one use to another. A vacant site changes entirely to residential use or to commercial use, it doesn't remain partly vacant. The discrete nature of land-use change obscures the larger fact that the process of land-use change is complex and that the causes of land-use change are myriad. Sites may change use because they are surrounded by similar sites in other uses. Or because they are located in or near growing cities or neighborhoods. Or because they are less expensive and more profitable to develop than other nearby sites. Or because the site is rendered more valuable through the extension of a public investment such as a road or a transit line. Or because after refusing developer offers for 10 years, the site owner is approached by a developer who offers the "right" price. All of these factors, singly and in combination, affect land-use change. Some of these factors — initial use, for example — are discrete. Others — for example, distance to a rapid transit station — vary continuously.

Regression models of the type developed in Chapters Three and Four are generally inappropriate when one wishes to analyze discrete choices or discrete changes as a function of multiple continuous and discrete factors. Logistic models, or "logit" models, are more appropriate in such cases.

Discrete Choice Models — An Introduction

Logit models were first applied to the analysis of discrete choices, not discrete changes. For the binary case (selection from among two alternatives), the logit model takes the following general form:

$$\text{Prob}\,[0\{0,1\}] = e^{U0} / (e^{U0} + e^{U1})$$

where:

U: is linear (utility) function of *n* independent variables or factors (Xi): $a + b_1X_1 + b_2X_2 + ... + b_nX_n$

Prob [[0{0,1}]: is the probability that an observation will select choice 0 from the binary choice set of 0 or 1 as a function of Xi

a and b_i are parameters of the linear function U, which must be estimated.

Although logit models are used to analyze discrete choices, the logistic probability function is itself continuous. By convention, probability values that exceed .5 are assigned the value of 1; probability values less than .5 are assigned a value of 0. Model parameters (the values of a and b_i) are usually estimated using the maximum likelihood method. When the choice set includes more than two alternatives, the multi-nomial form of the logit model is used:

$$\text{Prob}\,[i{:}\ j] = e^{Ui} / \ (e^{U0} + e^{U1})$$

where:

U:	is linear (utility) function of *n* independent variables or factors (Xi): $a + b_1X_1 + b_2X_2 + ... + b_nX_n$
Prob [[i{j}]:	is the probability that an observation will select choice i from a choice set including j elements, as a function of Xi
a and b_i	are parameters of the linear function U, which must be estimated.

Underlying both the binary and multi-nomial forms of the logit model is the assumption that the distribution of the error term follows a Gumbel distribution. Logit models have seen their widest application in the area of travel demand forecasting, particularly for making predictions of individual mode choice (Ben-Akiva and Lerman, 1985).

Extending the use of logit analysis to modeling discrete land-use changes requires relaxing a couple of the key assumptions. First, logit models are usually used to predict discrete choices by individuals based on the assumption that those individual choose the alternatives that maximize their own utility.[18] In this application, we will use logit analysis to predict discrete changes to hectare grid-cells and land-use polygons based on the assumption of maximized profitability. Second, and accordingly, the assumption that the error term follows a Gumbel distribution must also be relaxed.

Model Specifications

All seven of the logit models developed in this chapter are used to explain changes in dominant land uses as coded and counted at the hectare-grid-cell level. The hectare grid-cells upon which the models are based are limited to those which are within a half-mile or mile radius of the nine BART stations and four San Diego Trolley stations identified above. All but one of the models presented below are binary, or *binomial,* change models, in which the dependent variable measures the probability that a particular hectare grid-cell changed use during the study period. Sites that changed use during the study period are assigned a value of 1; those that did not change use are assigned a value of 0.

A final logit model of vacant land change takes a multi-nomial form. That is, two or more alternative developed uses are considered simultaneously. The multi-nomial model has an ordinal structure. This means that larger values of the dependent variable indicate higher-order land-use changes. Vacant sites that remained vacant during the study period were coded to a 1. Vacant grid-cells that were developed in residential use were coded to a 2. Vacant sites that were developed in commercial use were coded to a 3.

Six sets of independent variables are included as explanatory factors in the models that follow :

1. *Distance to the Nearest Transit Station*: This, of course, is the primary variable of interest. All else being equal, we hypothesize that grid-cells closer to transit stations are more likely to be developed, or otherwise change use, than more distant grid-cells. To incorporate this effect, we measure the straight line distance between each grid-cell and the nearest transit station. *BART_DIST* measures this effect for the nine BART stations; *TROLLEY_DIST* measures it for the four San Diego Trolley stations. Following our hypothesis, above, we would expect *BART_DIST* and *TROLLEY_DIST* each to have a negative coefficient.

2-3. *Initial Land Use:* The likelihood that a site will change land use depends to some extent on its initial use. Generally speaking, we would expect undeveloped sites to be more likely to change use than already-developed sites. Among already-developed land types, we hypothesize that lower-order uses (e.g, residential) are more likely to change to higher-order uses (e.g., commercial), than vice versa. To incorporate this effect into the model, we created two dummy variables: *INIT_USE—Undeveloped* designates undeveloped land, and is set equal to 1 if the initial land-use type is undeveloped, and to 0 if the initial use is developed. *INIT_USE—Residential* designates residential use: it is set equal to 1 if the initial land-use type is residential, and to 0 if the initial use is non-residential.

4. *Adjacent Land Uses*: All else being equal, we would expect site land uses to be strongly affected by the pattern of neighboring, or adjacent, uses. We would expect, for example, that a vacant site surrounded by residential uses would tend to be developed to residential use. The same would hold true for a vacant site surrounded by commercial uses; all else being equal, we would expect it to be developed to commercial use. There are three reasons why we would expect grid-cells to convert to uses similar to those that surround them. First, it may be cheaper to extend appropriate infrastructure and public facilities. Second, there may be agglomeration economies associated with larger areas of like use. Third, local land-use regulations may specify neighborhoods or clusters of similar uses.

To measure this effect we developed the index variable, *SIM_INDX*. *SIM_INDX* measures the similarity of each grid-cell to adjacent grid-cells, and is defined as the proportion of the same land-use type in the surrounding eight grid-cells. *SIM_INDX* varies between 0 and 1: A value of 1 means that a particular grid-cell is completely surrounded by cells of similar use. A *SIM_INDX* value of .5 would mean that half of the surrounding grid-cells are of similar use. Given that we expect higher rates of land-use change across borders of dissimilar land uses, we hypothesize that the estimated coefficient of *SIM_INDX* should be negative.

More refined measures of adjacent land use are used in the vacant land development models. *ADJ_Residential* measures the proportion of adjacent initial land uses in residential use. *ADJ_Commercial* measures the proportion of adjacent initial land uses in commercial uses. Like *SIM_INDX*, *ADJ_Commercial* and *ADJ_Residential* vary between 0 and 1, depending on the mix of adjacent uses. Unlike *SIM_INDX*, however, their respective values increase with the share of higher-order adjacent uses. Thus, all else being equal, we would expect their coefficients to be positive.

5. *Available Vacant Land:* As noted above, development occurs more frequently on undeveloped or vacant sites than on previously-developed sites. All else being equal, we would thus expect more development to occur near transit stations surrounded by vacant land than near stations surrounded by developed land. The variable *VACANT-AVAIL* measures the availability of undeveloped land. It measures the share of undeveloped land near a transit station that is closer to the station than a particular grid-cell. Suppose, for example, that there are 50 and 500 acres, respectively, of undeveloped land within a quarter-mile and half-mile radius of a particular transit station, and that a particular undeveloped site-of-interest is located a quarter mile from the station. This means that only 10 percent of available vacant land is closer to the transit station than site of interest (the value of *VACANT_AVAIL* would be .1 for the particular site of interest). All else being equal, we would expect the comparative lack of vacant land closer to the transit station than the site-of-interest to make the site more valuable, and thus more likely to be developed. Put another way, we would expect the coefficient of *VACANT_AVAIL* to be negative: vacant sites near transit stations are likely to be developed according to their relative supply as well as their proximity.

6. *Characteristics of Individual Transit Stations*: Each of the nine BART and four San Diego Trolley stations is in a slightly different property market. Thus, factors which induce land-use changes at some stations may not induce changes at others. Including dummy variables for each station area in the various models enables us to capture these differences.

5.3. Model Results: Explaining Patterns of Land-Use Change

What is the likelihood that a given hectare grid-cell will change land use as a function of its distance from a BART or San Diego Trolley station? The results of various binomial logit models predicting land-use changes (of all types) are shown in Tables 5.3 through 5.6. Tables 5.3 and 5.4 refer to land-use changes near BART stations; Table 5.5 and 5.6 refer to land-use changes near San Diego Trolley stations.

Table 5.3: Binomial Logit Model Results for Grid-Cell Land Use Changes at Selected BART Stations: 1965-75 and 1975-90

Dependent Variable: Hectare Grid-Cell Land Use Change (0=no, 1 = yes)

	Model Coefficents and Statistics by Period	
	1965-75	1975-90
Independent Variables		
BART_DIST	0.004	0.002
VACANT_AVAIL	-0.015	not significant
INIT_USE-U	1.321	7.498
INIT-USE-R	not significant	2.111
SIM_INDX	not significant	-0.044
Station Area Dummy Variables		
CONCORD	2.63	not significant
FREMONT	2.77	-0.96
HAYWARD	not significant	1.10
PLEASANT HILL	2.44	not significant
ROCKRIDGE	not significant	not significant
UNION CITY	4.01	1.66
WALNUT CREEK	3.54	1.20
DALY CITY	not significant	-0.46
Constant	-7.91	-3.24
Observations	2434	2315
Changed Grid Cells	320	533
% Predicted	27.2%	76.7%
Unchanged Grid Cells	2112	1782
% Predicted	98.3%	96.4%
Overall fit	88.8%	91.9%

Table 5.4: Binomial Logit Model Results for Grid-Cell Land Use Changes at Each BART Station: 1965-90

Dependent Variable: Hectare Grid-Cell Land Use Change (0=no, 1 = yes)

	BART Station Area (n/s indicates variable is not statistically significant)								
	Concord	Walnut Creek	Union City	Fremont	Hayward	Pleasant Hill	Daly City	Rock-ridge	El Cer-rito del Norte
Independent Variables									
BART_DIST	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
VACANT_AVAIL	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
INIT_USE-	n/s	n/s	13.58	3.63	6.36	n/s	6.33	n/s	n/s
INIT-USE-	1.2578	3.08	2.91	n/s	n/s	n/s	2.06	4.6257	4.907
SIM_INDX	-0.0269	-0.0455	-0.0724	-0.0399	-0.0267	-0.0087	n/s	-0.0629	0.0004
Constant	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
Observations	306	274	318	300	226	243	273	248	235
Changed Grid Cells	48	148	214	170	46	28	46	18	23
% Predicted	34.8%	90.5%	97.7%	85.9%	50.0%	78.6%	65.2%	16.7%	69.6%
Unchanged Grid Cells	260	126	104	130	180	215	227	230	212
% Predicted	100.0%	96.8%	96.2%	47.7%	97.8%	99.1%	96.5%	99.6%	99.1%

BART Station Results

Table 5.3 presents the binomial logit model results of land-use change within a half-mile of nine BART stations during two periods: 1965-75 and 1975-90. As noted above, the first of these periods includes the period of BART's construction but not operation. The second period covers the first 15 years of BART operations. Five independent variables were included in the model, as were eight of the nine BART station area dummy variables. Note that this model predicts only the occurrence of a grid-cell land-use change (of any type), not the specific type of land-use change.

Three-hundred twenty grid-cells changed land uses between 1965 and 1975. The model predicts only 27.2 percent of those changes, a relatively poor result. Only three of five independent variables were statistically significant. The coefficient sign for *BART_DIST* (the variable measuring distance to the nearest transit station) was positive — the opposite of what was expected. Five of the eight station dummy variables were statistically significant, and all had positive coefficients. The probability of a particular grid-cell changing land use during the 1965-75 period was highest near the Union City BART station (estimated coefficient = 4.01) and lowest near the Pleasant Hill station (estimated coefficient = 2.44).

Table 5.5: Binomial Logit Model Results for Grid-Cell Land Use Changes at Selected San Diego Trolley Stations: 1985-94

Dependent Variable: Hectare Grid-Cell Land Use Change

	Model Coefficents and Statistics
Independent Variables	
TROLL_DIST	-0.003
VACANT_AVAIL	0.029
INIT_USE-Undeveloped	2.861
INIT-USE-Residential	-0.782
INIT-USE-Other	-5.021
SIM_INDX	-0.010
Constant	-1.92
Observations	2,012
Changed Grid Cells	113
% Predicted	9.7%
Unchanged Grid Cells	1,899
% Predicted	99.9%

The same specification does a much better job predicting grid-cell land-use change between 1975 and 1990. The model correctly predicted 409 of 533 grid-cell land-use changes (76.7 percent). Four of the five independent variables were statistically significant. The one that was not was *VACANT_AVAIL*, which suggests that the availability of vacant land was not a significant determinant of station area land-use change during the 1975-90 period. As in the previous period, sites closer to BART stations were *not* more likely to change uses than more distant sites. Five of the eight station dummy variables were statistically significant. As in the previous period, the probability of a particular grid-cell changing land use during the 1965-75 period was highest near the Union City BART station (estimated coefficient = 1.66), followed by the Walnut Creek and Hayward station areas. The probability of a particular grid-cell near the Fremont or Daly City BART stations changing land uses between 1975 and 1990 was negative. What this means is that after accounting for effects of the pattern of initial uses and proximity to BART, grid-cells near the Fremont and Daly City BART stations were unlikely to change land uses between 1975 and 1990.

A second table (Table 5.4) includes separate model runs for each of the nine BART station areas. Because of a lack of observations during the separate 1965-75 and 1975-1990 periods, results are reported over the entire 1965-1990 period. Not surprisingly, the model fits vary widely across station areas. The best-fitting model is for the Union City BART station area. In this model, the combination of *SIM_ INDX* (indicating the proportion of adjacent grid-cells of similar initial use), *INIT-USE-Undeveloped* (indicating that the grid-cell was originally undeveloped), and *INIT-USE-Residential* (indicating that the

Table 5.6: Binomial Logit Model Results for Grid-Cell Land Use Changes at Each San Diego Trolley Station: 1985-94

Dependent Variable: Hectare Grid-Cell Land Use Change (0=no, 1 = yes)

	San Diego Trolley Station Area (n/s indicates variable is not statistically significant)			
	Amaya	El Cajon	Palm	Spring
Independent Variables				
TROLLEY_DIST	0.0096	n/s	n/s	n/s
VACANT_AVAIL	-0.1439	n/s	n/s	n/s
INIT_USE-Undeveloped	3.95	1.24	10.74	2.0894
INIT-USE-Residential	n/s	-2.28	n/s	-1.7905
INIT-USE-Other	n/s	n/s	n/s	n/s
SIM_INDX	-0.0664	-0.011	-0.0257	0.0125
Constant	-6.7929	n/s	n/s	-3.2712
Observations	659	495	549	309
Changed Grid Cells	18	20	46	29
% Predicted	34.8%	30.0%	6.5%	34.5%
Unchanged Grid Cells	641	475	503	280
% Predicted	99.1%	99.4%	98.8%	99.3%

grid-cell was originally in residential use) explain 146 out of 170 land-use changes during the 1965-90 period. The same variables explained 90.5 percent of land-use changes near the Walnut Creek BART station, and 85.9 percent of land-use changes near the Fremont BART stations. The worst-fitting models are those in which few grid-cells changed land use. For example, only 18 grid-cells near the Rockridge station changed use between 1965 and 1990; and the model "explains" only three of those (16.7 percent). Similarly, the model explains only a third of the 48 grid-cells that changed use at the Concord BART station between 1965 and 1990. *In none of the models — regardless of fit — was BART_DIST (the variable measuring proximity to a BART station) found to be statistically significant.* Regardless of the station area considered, proximity to a BART station was not a determinant of land-use change at the hectare grid-cell level.

San Diego Trolley Station Results

Altogether, the four San Diego Trolley stations areas included in this analysis — Amaya, El Cajon, Palm, and Spring — encompass 2,012 hectare grid-cells. Of this total, 113 grid-cells changed land uses between 1980 and 1994. The binomial land-use change model presented in Table 5.5 correctly explains fewer than 10 percent of those changes. Despite the poor overall "fit" of the model, all of the included independent variables were found to be statistically significant. As hypothesized, the coefficient estimate of *TROLLEY_DIST* (the distance between each grid-cell and the nearest transit station) is negative, indicating that those grid-cells close to the four Trolley stations were more likely to change uses than more distant grid-cells. Also as expected, each grid-cell's initial land use was found to affect its likelihood of subsequently changing use. Undeveloped grid-cells were more likely to change use between 1980 and 1994, while residential and commercial grid-cells were less likely to change use. The coefficient estimate for *SIM_INDX* (a measure indicating the extent to which a particular grid-cell was surrounded by grid-cells of similar use) was found to be negative, another expected result. Contrary to expectations, the coefficient estimate for *VACANT_AVAIL* (measuring the availability of undeveloped land) was found to be negative. Combining these various effects, those grid-cells which were most likely to change land use between 1980 and 1994 were those that were initially undeveloped, adjacent to the Trolley station, and surrounded by developed and dissimilar uses. By contrast, the types of grid-cells least likely to change land use between 1980 and 1994 were initially in residential or commercial use, were surrounded by grid-cells of similar use, and were more distant from the Trolley.

A second table (Table 5.6) includes separate model runs for each of the four Trolley stations. The model correctly predicts about a third of the 1980-94 grid-cell land-use changes for the three Trolley stations on the East-West line (Amaya, El Cajon, and Spring), but only 6.5 percent of land-use changes in the vicinity of the Palm Street. *In none of the four models was TROLLEY_DIST (the variable measuring proximity to a Trolley station) found to be statistically significant or of the expected sign.* When considered on a station area-by-station area basis, proximity to the Trolley station was not found to be a determinant of land-use change at the hectare grid-cell level.

5.4. Patterns of Vacant Land Development

Most land-use changes involve the development of vacant land. As Figure 5.4 shows, __ percent of 1965-1990 land-use changes at the nine case-study BART stations, and __ percent of 1980-95 land-use changes at the four case-study San Diego Trolley stations, involved the conversion of previously undeveloped land to some other use. This section explores the extent to which patterns of vacant land development near rapid transit stations differ from overall patterns of land-use change.

Patterns of Residential Development

As of 1965, there were 544 undeveloped hectare grid-cells within a half-mile of the nine BART stations included in this analysis. Between 1965 and 1975, 36 of those undeveloped grid-cells were converted to residential uses. An additional 97 hectare grid-cells were converted to residential uses between 1975 and 1990. The binomial logit model included as Table 5.7 does a poor job explaining undeveloped-to-residential grid-cell land-use changes during the first of these two periods (6.6 percent of changes correctly predicted) , but a fairly good job explaining them during the second period (83.5 percent of changes predicted correctly). Regardless of the period, the coefficient of the *BART_DIST* variable was

Table 5.7: Binomial Logit Model Results for Grid-Cell Land Use Changes [Undeveloped to Residential] at Selected BART and San Diego Trolley Stations

Dependent Variable: Hectare Grid-Cell Land Use Change from Undeveloped to Residential Use

	Model Coefficents and Statistics		
	BART: 1965-75	**BART: 1975-90**	**SD Trolley: 1980-94**
Independent Variables			
BART_DIST or	0.008	0.008	0.0043
ADJ_RES	not significant	0.043	-0.0156
VACANT_AVAIL	not significant	not significant	-0.0681
Station Area Dummy			
CONCORD	not significant	not significant	
FREMONT	not significant	not significant	
HAYWARD	not significant	not significant	
PLEASANT HILL	not significant	not significant	
ROCKRIDGE	not significant	not significant	
UNION CITY	not significant	not significant	
WALNUT CREEK	not significant	not significant	
DALY CITY	not significant	not significant	
AMAYA			-1.667
EL CAJON			-1.7085
PALM			-2.1099
Constant	-38.80	26.37	not significant
Observations	544	278	430
Changed Grid Cells	36	97	119
% predicted by model	6.6%	83.5%	12.6%
Unchanged Grid Cells	508	181	311
% predicted by model	93.4%	80.1%	94.9%

found to be positive. This means that the vacant grid-cells close by BART stations were less likely to be developed in residential use than more distant grid-cells.

What about new residential development near San Diego trolley stations? As of 1980, there were 430 undeveloped hectare grid-cells within a half-mile of the Amaya, El Cajon, Palm, and Spring Street San Diego Trolley stations. During the next 14 years, 119 of those undeveloped grid-cells would be converted to residential uses. The binomial logit model summarized in Table 5.7 correctly explains only about one-eighth of those changes. As with BART, the further an undeveloped grid-cell was from a San Diego Trolley station, the more likely it would be developed to a residential use. Compared with sites near the Spring Street Station, vacant sites near the Amaya, El Cajon, and Palm stations were less likely to be developed to residential use. As expected, the sign of the coefficient for *VACANT_AVAIL* (the share of vacant land closer to the transit station than a given grid-cell) was found to be negative, indicating that vacant sites immediately proximate to Trolley stations were more likely to be developed to residential use than more distant vacant sites. Finally, we note that the coefficient sign for *ADJ_Residential* was found to be negative, indicating that vacant sites surrounded by residential uses were less likely (not more likely) to be developed into residential use.

Patterns of New Commercial Development

It is sometimes argued that transit investments should stimulate nearby commercial development. To what extent was this true for BART and the San Diego Trolley? Between 1965 and 1975, 72 of 580 undeveloped hectare grid-cells near the nine case-study BART stations were converted to commercial uses. An additional 257 hectare grid-cells were converted to commercial uses between 1975 and 1990. The binomial logit model included as Table 5.8 does a poor job explaining undeveloped-to-residential grid-cell land-use changes during the first of these two periods (4.6 percent of changes correctly predicted), but a fairly good job explaining them during the second period (89.1 percent of changes predicted correctly). Regardless of the period, the coefficient of the *BART_DIST* variable was found to be positive. This means that those vacant grid-cells closest to BART stations were actually less likely to be developed to commercial use than more distant grid-cells. The share of adjacent grid-cells initially in commercial use (*ADJ_Commercial*) was found to be positive for the first of these two periods, but negative for the second. This indicates that vacant sites near BART stations surrounded by commercial uses were more likely to be developed to commercial use between 1965 and 1975, but less likely to be developed to commercial use (compared with other uses) between 1975 and 1990.

What about new commercial development near San Diego Trolley stations? As of 1980, there were 478 undeveloped hectare grid-cells within a half-mile of the Amaya, El Cajon, Palm, and Spring Street San Diego Trolley stations. During the next 14 years, 100 of those undeveloped grid-cells would be converted to commercial uses. The binomial logit model summarized in Table 5.8 correctly explains only about one-ninth of those changes. Despite its poor overall fit, the San Diego model does offer some interesting insights. As expected, the sign of the *TROLLEY_DIST* coefficient is negative, indicating that closer vacant sites were more likely to be developed in commercial uses than more distant ones. The positive sign for the *ADJ_COMMERCIAL* coefficient is also consistent with expectations. It indicates that vacant sites surrounded by sites already in commercial use were themselves likely to be developed to commercial use.

Patterns of Residential and Commercial Development: Results of the Multi-Nomial Model

All of the logit models developed thus far have been of a binary, or binomial, form. That is, they have been used to determine why one particular type of land-use change occurred. Binomial models

Table 5.8: Binomial Logit Model Results for Grid-Cell Land Use Changes [Undeveloped to Commercial] at Selected BART and San Diego Trolley Stations

Dependent Variable: Hectare Grid-Cell Land Use Change from Undeveloped to Commercial Use

	Model Coefficents and Statistics		
	BART: 1965-75	**BART: 1975-90**	**SD Trolley: 1980-94**
Independent Variables			
BART_DIST or	0.039	0.006	-0.0049
ADJ_Commercial	0.000	-0.022	0.0228
VACANT_AVAIL	-0.032	not significant	0.0513
Station Area Dummy			
CONCORD	not significant	not significant	
FREMONT	not significant	not significant	
HAYWARD	not significant	not significant	
PLEASANT HILL	not significant	not significant	
ROCKRIDGE	not significant	not significant	
UNION CITY	not significant	not significant	
WALNUT CREEK	not significant	not significant	
DALY CITY	not significant	not significant	
AMAYA			not significant
EL CAJON			not significant
PALM			not significant
Constant	not significant	not significant	0.9596
Observations	580	354	478
Changed Grid Cells	72	257	100
% predicted by model	4.2%	89.1%	11.0%
Unchanged Grid Cells	508	97	378
% predicted by model	99.8%	59.7%	97.9%

cannot be used to analyze multiple choices, or multiple change possibilities. The multi-nomial form of the logit model is more appropriate for that purpose.

Table 5.9 presents the results of a multi-nomial logit model of land-use changes to undeveloped hectare grid-cells near the nine case-study BART stations and four case-study San Diego Trolley stations. Three land-use change possibilities are considered: (i) that an undeveloped grid-cell remains undeveloped; (ii) that an undeveloped grid-cell is developed to residential use; and (iii) that an undeveloped grid-cell is developed to commercial use. The three possibilities are assumed to be ordinal. This means that a land-use change to a commercial use is presumed to be a higher-order change than land-use change to a residential use, and that land-use change to residential use is presumed to be of a higher-order change than

Table 5.9: Multinomial Logit Model Results for Undeveloped Grid-Cell Land Use Changes at Selected BART and San Diego Trolley Stations

Dependent Variable: Undeveloped Grid Cell Land Use Change
1: No change to undeveloped land
2: Undeveloped to residential use
3: Undeveloped to commerical use

	Model Coefficents and Statistics		
	BART: 1965-75	**BART: 1975-90**	**SD Trolley: 1980-94**
Independent Variables			
BART_DIST or	not significant	not significant	not significant
ADJ_Residential	not significant	-0.010	not significant
ADJ_Commercial	0.021	0.047	0.023
VACANT_AVAIL	not significant	not significant	not significant
Station Dummy Variables			
CONCORD	not significant	not significant	
FREMONT	not significant	-1.93	
HAYWARD	not significant	not significant	
PLEASANT HILL	3.27	not significant	
ROCKRIDGE	not significant	not significant	
UNION CITY	not significant	not significant	
WALNUT CREEK	not significant	not significant	
DALY CITY	not significant	-1.86	
AMAYA			not significant
EL CAJON			not significant
PALM			not significant
Constant 1	-3.55	-1.17	-1.008
Constant 2	-3.02	1.20	not significant
Observations	613	491	406
Change = 1	508	97	311
Change = 2	36	181	53
Change = 3	69	213	42
%Concordant Predictions	58.8%	81.6%	67.9%
%Discordant Predictions	28.1%	18.1%	31.1%
%Tied Predictions	13.1%	0.3%	1.0%

for a site to remain undeveloped. The value of this type of specification is that it allows different forms of development to be examined as alternatives to each other, not just to no development.

As in previous models, our analysis of land-use change near BART stations is divided into two periods: (i) a pre-BART period spanning the years 1965-1975; and (2) a BART-operations period encompassing the years 1975-90. The multi-nomial logit model summarized in Table 5.9 correctly explains 58.8

percent of undeveloped land-use changes near the nine case-study BART stations between 1965 and 1975, and 81.6 percent of land-use changes near the same nine BART stations between 1975 and 1990. In neither period was proximity to the BART station (*BART_DIST*) found to be statistically insignificant. Vacant grid-cells surrounded by commercial uses (*ADJ_Commercial*) were somewhat more likely to be commercially developed themselves during the 1965-75 period, and much more likely to be commercially developed during the 1975-90 period. Vacant grid-cells surrounded by residential uses (*ADJ_Residential*) were no more likely to be developed to residential use during the 1965-75 period (than to remain undeveloped), and actually less likely to be developed to residential use during the 1975-90 period. The relative availability of vacant land (*VACANT_AVAIL*) did not affect the likelihood of commercial or residential development in either period. All else being equal, undeveloped grid-cell near the Pleasant Hill BART station were more likely to be developed to commercial use between 1965 and 1975, but not between 1975 and 1990. All else being equal, undeveloped grid-cells near the Fremont and Daly City stations were somewhat more likely to remain undeveloped during the 1975-90 period.

Turning southward, the multi-nomial logit model summarized in Table 5.9 correctly explains 67.9 percent of undeveloped land-use changes near the four case-study San Diego Trolley stations between 1980 and 1994. As with the BART, above, station proximity (*Trolley_DIST*) was not found to be a statistically significant predictor of land-use change. Indeed, of the seven independent variables considered, the only one which was found to be significant was ADJ_COMMERCIAL — indicating that grid-cells surrounded by commercial uses were somewhat more likely to be developed than other grid-cells.

5.5 Summary and Interpretation

Summary

Whether it is based on an analysis of maps, or data in tables, or the results of statistical models, whether it is based on a partial analysis or a multi-variate one, the overall finding of this chapter is consistently the same: *neither BART nor the San Diego Trolley has had a significant effect on land-use patterns in their immediate station areas.* Among the major findings of this chapter:

- There has been a significant amount of land-use change near many BART stations since 1965. Altogether, 1,557 acres of land area (within a half-mile of nine representative BART stations) classified as vacant or undeveloped in 1965 were developed by 1990. Of this total, 41 percent were converted to residential uses, 21 percent were converted to commercial uses, 16 percent were converted to public uses, 15 percent were converted to industrial uses, and 7 percent were developed as roads, transit right-of-way, or parking lots. Most of these changes occurred between 1975 and 1990. Taken together, they resulted in a slight — although significant — shift in the pattern of BART station area land uses toward residential and commercial uses.

  Various statistical models were developed to separate the effect of proximity to the BART station itself as a determinant of station area land-use change, from other factors. In none of the models tested — whether for all land-use changes, changes to vacant land in general, or specific forms of vacant land change — was proximity to a BART station found to be a significant determinant of land-use change.

- Our analysis of land-uses changes near San Diego Trolley stations included only four station areas — Amaya, El Cajon, Palm, and Spring Street. Altogether, 163 acres of land classified as vacant or undeveloped in 1980, and within a half-mile of these four stations, were developed by 1990. As in the case of BART, the sum total of these changes resulted in a slight but significant shift in the pattern of station area land uses toward residential and commercial uses. Also, as in the BART case, proximity to a Trolley station was not found to be a significant determinant of vacant or developed land-use change — even holding constant other development-related factors.

Interpretation

One can posit four reasons why sites near selected BART and San Diego Trolley stations did not change use, or were not developed with greater frequency than more distant sites. The first reason is really more of a caveat: perhaps we simply selected the wrong stations areas to examine. Had we looked at all BART and San Diego Trolley stations, or at other stations, perhaps we would have found a more significant relationship between land-use change and station proximity. While this argument has some validity, it disregards the fact that we selected the case study stations to be broadly representative, and because they were in areas with more opportunities — not fewer — for significant land-use changes. Related to this argument is another one — that 10 or 15 years is simply too short a period in which to observe significant land-use changes. Yet, as we note in the next chapter, during the same period that extensive land-use changes were not taking place near BART stations, they were taking place in other, not-so-faraway locations.

Second, the study areas around the selected BART and San Diego Trolley stations may not be large enough to observe significant patterns of land-use change. We return to this issue in the case of BART in the next chapter.

A third reason for not finding a relationship between proximity to transit stations and land-use change is more compelling. It is that regardless of the opportunities for development and/or land-use change, there may be significant institutional barriers to such change. Such barriers can take the form of organized neighborhood opposition, as in the case of the Rockridge BART station; in inflexibly applied zoning and subdivision ordinances; in the fragmented nature of parcel boundaries (making land assembly more difficult); or in the inability of local governments to provide necessary development incentives. Of all the (non-downtown) BART stations, the Fremont and Walnut Creek station areas have experienced the most new development in their immediate station areas since 1965. Compared to the other three terminal stations (Concord, Daly City, and Richmond), there was more developable land available near the Fremont station, parcel sizes were considerably larger, and local regulations were more conducive to a broader range of development forms. In the case of Walnut Creek, city policies explicitly favored the development and redevelopment of sites near the BART stations.

A fourth reason is both simpler and perhaps closer yet to the truth. It is that the presence of a transit station — in and of itself — has little ability to stimulate land-use change or new development.

CHAPTER SIX:
BART and Metropolitan Land-Use Change: 1985-1990

by John Landis and Ming Zhang

Once upon a time, most people who took rail transit walked to and from the station. Today, although many transit riders still walk to the station (particularly in older cities like Boston and New York City), more and more transit riders arrive by private car. At the other end of the transit trip, most riders still walk from the transit station to their final destination. The effect of this change in access mode has been to expand transit's market area (or access shed) on the origin side of the transit trip, but not necessarily on the destination side.

Writing in 1962, historian Sam Bass Warner introduced the term, "streetcar suburbs": neighborhoods within walking access to Boston trolley lines developed at the end of the 19th century. Thirty years later, in California, similar suburban communities developed around the Key Line in the San Francisco Bay Area, and around the Red Line in Los Angeles. To what extent did the construction of BART replicate this phenomenon, but within a greater radius to match the system's larger access sheds? Put another way, to what extent did the development of BART accelerate the conversion and development of land at a metropolitan scale?[19] This chapter tries to answer that question. Using the same types of models as in Chapter Five, it examines the role of BART station access in determining patterns of land-use change in Alameda and Contra Costa Counties between 1985 and 1990. Part 6.1 introduces the data set used for this analysis, and describes the extent of land-use changes in Contra Costa and Alameda Counties between 1985 and 1990. Part 6.2 outlines the development of a statistical model designed to isolate the effect of BART access on land-use change; Part 6.3 reports on the model results; and Part 6.4 discusses the implications of those results.

6.1. Alameda and Contra Costa County Land-Use Changes: 1985-1990

Before one can analyze land-use changes, one must be able to locate them. As noted in Chapter Five, the only multi-year detailed inventory of land uses currently available in California is published by the Association of Bay Area Governments (ABAG). The ABAG database lists the dominant use of every hectare (100m x 100m land area) of land within the nine-county San Francisco Bay Area at two points, 1985 and 1990. Converting the ABAG database into a form which could be used to analyze the relationships between land-use change and BART access involved a four-step process:

> 1. The 1985 and 1990 land-use inventories were separately converted into map form. Simultaneously, the number of land-use categories were reduced from several dozen to seven: (i) residential; (ii) commercial; (iii) public and institutional; (iv) industrial; (v) transportation; (vi) vacant and undeveloped; and (vii) unclassified.

2. Using Arc/Info, a geographic information system, adjacent hectare grid-cells with the same use category were merged (or "dissolved") into land-use polygons.

3. Using Arc/Info, the 1985 and 1990 maps were geometrically combined (or "unioned") into a single map identifying those land-use polygons that *changed use* between 1985 and 1990.

4. Arc/Info was then used to measure the aerial distance between every land-use polygon (whether or not it changed use) and the nearest BART station and freeway interchange.

Land-Use Changes in Alameda and Contra Costa Counties: 1985-90

The 1985-90 period witnessed considerable land development in both Alameda and Contra Costa Counties. Altogether, 6,634 acres of land area in Alameda County changed use between 1985 and 1990 (Table 6.1). Except for 238 acres, all of these changes involved the conversion of previously

Table 6.1: Changes in Alameda County Land Use Distribution: 1985-90

Dominant Land Use in 1985	Dominant Land Use in 1990	Acres	% of All Land Use Changes: 1985-90	% Change in Land Use Category
Unclassified	Other	5	0.0%	na
Undeveloped	Residential	3,796	57.2%	4.9%
	Commercial	1,818	27.4%	19.4%
	Public	257	3.9%	2.1%
	Industrial	472	7.1%	3.7%
Residential	Undeveloped	15	0.2%	0.0%
	Commercial	37	0.6%	0.4%
Commercial	Undeveloped	3	0.0%	0.0%
	Residential	90	1.4%	0.1%
	Public	5	0.0%	0.0%
Industrial	Residential	20	0.3%	0.0%
	Commercial	10	0.1%	0.1%
	Public	11	0.2%	0.0%
Transportation	Residential	20	0.3%	0.0%
	Commercial	17	0.3%	0.0%
	Public	10	0.1%	0.0%
All Land Uses	Undeveloped	30	0.4%	0.0%
	Residential	3,965	59.8%	5.1%
	Commercial	1,882	28.4%	20.1%
	Public	283	4.3%	2.4%
	Industrial	474	7.1%	3.7%
Total	**All Changes**	**6,634**	**100.0%**	

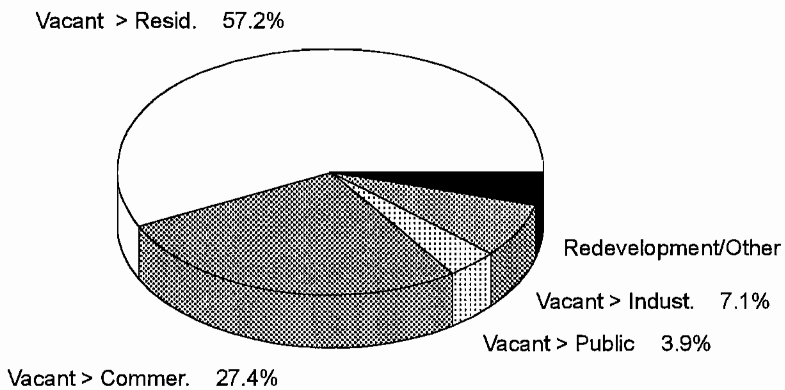
undeveloped land to a developed use. New residential development accounted for 59.8 percent of all land-use changes (+3,965 acres), followed by new commercial development (+28.4 percent; +1882 acres), new industrial development (7.1 percent; +474 acres), and new public uses (4.3 percent; +283 acres). The number of acres in transportation use (roads and transit systems and facilities) in Alameda County did not change at all between 1985 and 1990. Redevelopment — that is, a change from one developed use to another — accounted for only about four percent of land-use changes in Alameda County between 1985 and 1990 (Figure 6.1). The remaining 96 percent of land-use changes occurred through the development of previously undeveloped land.

These changes had little effect on the overall pattern of land uses in Alameda County (Figure 6.2). Residential uses, for example, increased from 15.2 percent of all land uses and 59.9 percent of developed land uses in 1985, to 16 percent of all land uses and 60 percent of developed land uses in 1990. Commercial uses increased from 12.2 percent of developed uses in 1985 to 13 percent of developed uses in 1990. The single biggest change, of course, was in the amount of undeveloped land, which declined from 74.2 percent of land uses in 1985 to 72.9 percent of land uses in 1990.

Contra Costa County experienced considerably more land-use change between 1985 and 1990 than did Alameda County. Altogether, 9,389 acres of land area in Alameda County changed use between 1985 and 1990 (Table 6.2). Except for 778 acres, all of these acreage changes involved the conversion of previously undeveloped land to a developed use. New residential development accounted for 81.9 percent of land-use changes (+7,689 acres) , followed by new public uses (10.7 percent; +1006 acres). New commercial and industrial development was relatively more modest, accounting for only 3.1 percent and .3 percent, respectively, of Contra Costa land-use changes between 1985 and 1990 (7.1 percent; +474 acres), and new public uses (4.3 percent; +283 acres). The number of acres in transportation use (roads and transit systems and facilities) in Alameda County grew by 215 acres between 1985 and 1990. Redevelopment accounted for about seven percent of land-use changes in Alameda County between 1985 and 1990, with most redevelopment consisting of changes from commercial and industrial lands to residential and public uses (Figure 6.3).

Although large in absolute magnitude, these changes had little effect on the overall pattern of land uses in Contra Costa County (Figure 6.4) Residential uses, for example, increased from 16.6 percent of all land uses and 67.3 percent of developed land uses in 1985, to 18.2 percent of all land uses and 68.7 percent of developed land uses in 1990. Commercial uses actually decreased from 8.1 percent of developed uses in 1985 to 7.7 percent of developed uses in 1990. Public and transportation uses stayed constant as a share of developed land uses, while industrial uses declined somewhat — from 11.1 percent in 1985, to 10.1 percent in 1990. Changes in vacant land shares in Contra Costa between 1985 and 1990 almost exactly matched those in next-door Alameda County, declining from 74.2 percent of land area in 1985, to 72.4 percent in 1990.

Figure 6.1: Composition of Alameda County Land Use Changes : 1985-90



1985-90 Acreage Land Use Changes

Figure 6.2: Alameda County Distribution of Developed Land Uses: 1985, 1990

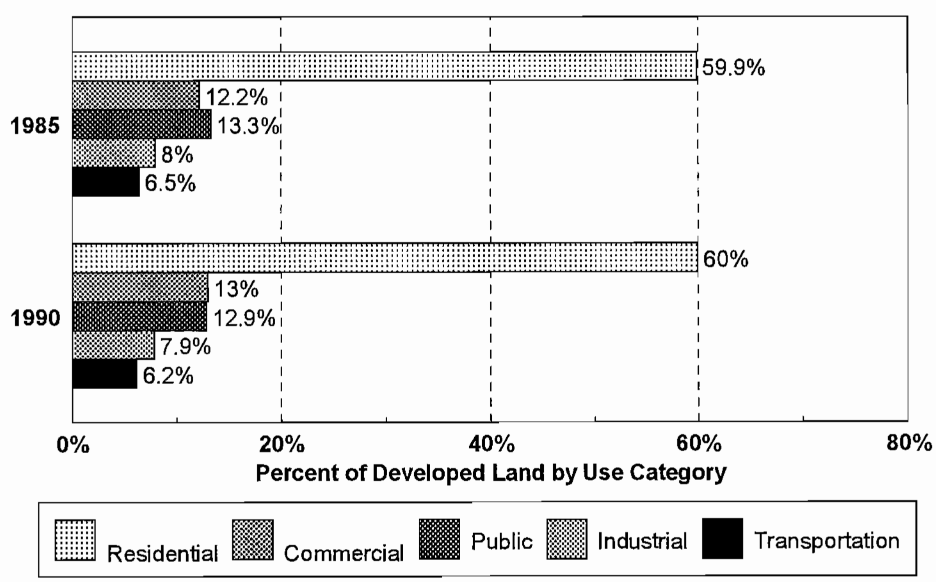


Table 6.2: Changes in Contra Costa County Land Use Distribution: 1985-90

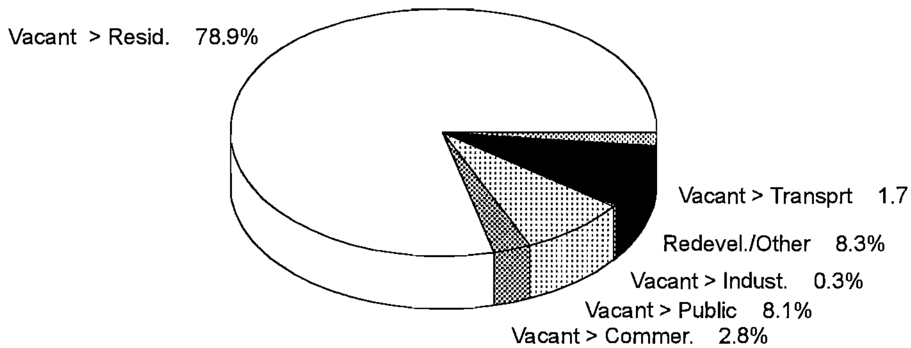
Dominant Land Use in 1985	Dominant Land Use in 1990	Acres	% of All Land Use Changes: 1985-90	% Change in Land Use Category
Unclassified	Other	30	0.3%	na
Undeveloped	Residential	7,406	78.9%	8.7%
	Commercial	264	2.8%	0.3%
	Public	756	8.1%	0.9%
	Industrial	25	0.3%	0.0%
	Transportation	158	1.7%	0.2%
Residential	Undeveloped	54	0.6%	0.0%
	Commercial	27	0.3%	0.0%
	Public	96	1.0%	0.1%
Commercial	Undeveloped	12	0.1%	0.0%
	Residential	62	0.7%	0.0%
	Public	12	0.1%	0.0%
	Transportation	3	0.0%	0.0%
Industrial	Undeveloped	79	0.8%	0.0%
	Residential	111	1.2%	0.1%
	Public	137	1.5%	0.2%
	Transportation	55	0.6%	0.0%
Transportation	Residential	5	0.0%	0.0%
All Land Uses	Undeveloped	163	1.7%	0.2%
	Residential	7,689	81.9%	9.0%
	Commercial	291	3.1%	0.3%
	Public	1,006	10.7%	1.2%
	Industrial	25	0.3%	0.0%
	Transportation	215	2.3%	0.3%
Total	**All Changes**	**9,389**	**100.0%**	

Patterns of Land-Use Change in Alameda and Contra Costa Counties

To what extent did the changes in land use identified above follow a pattern? In particular, how, if at all, did they vary according to distance to the nearest BART station, the nearest freeway interchange, or to Oakland, the regional employment center for Alameda and Contra Costa commuters?

Alameda County Land-Use Changes: Most land-use changes in Alameda County between 1985 and 1990 occurred one to four miles from a BART station (Figure 6.5a). In a further confirmation of the findings

Figure 6.3: Composition of Contra Costa County Land Use Changes : 1985-90



1985-90 Acreage Land Use Changes

Figure 6.4: Contra Costa County Distribution of Developed Land Uses: 1985, 1990

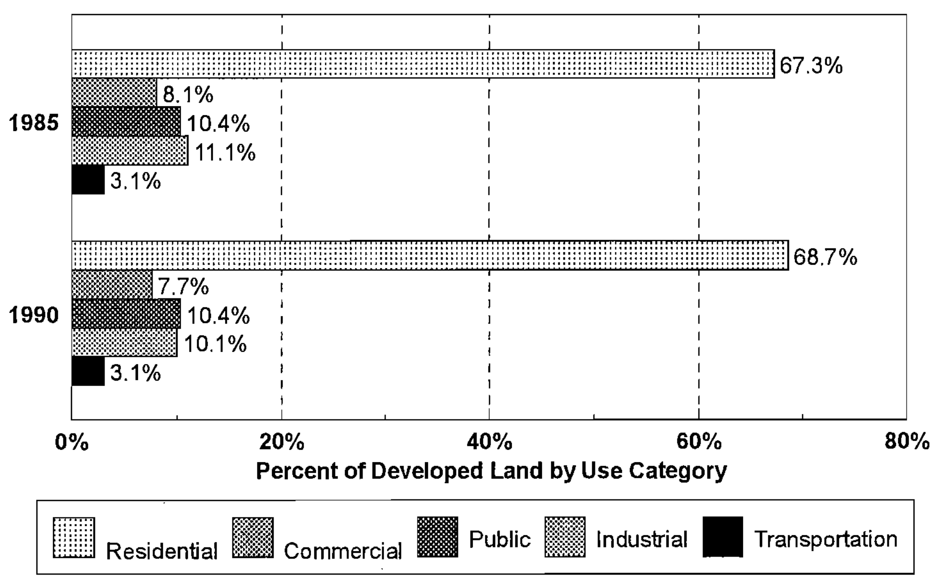


Figure 6.5a:
Alameda County Land Use Changes as a Function of Distance to the Closest BART Station: 1985-90

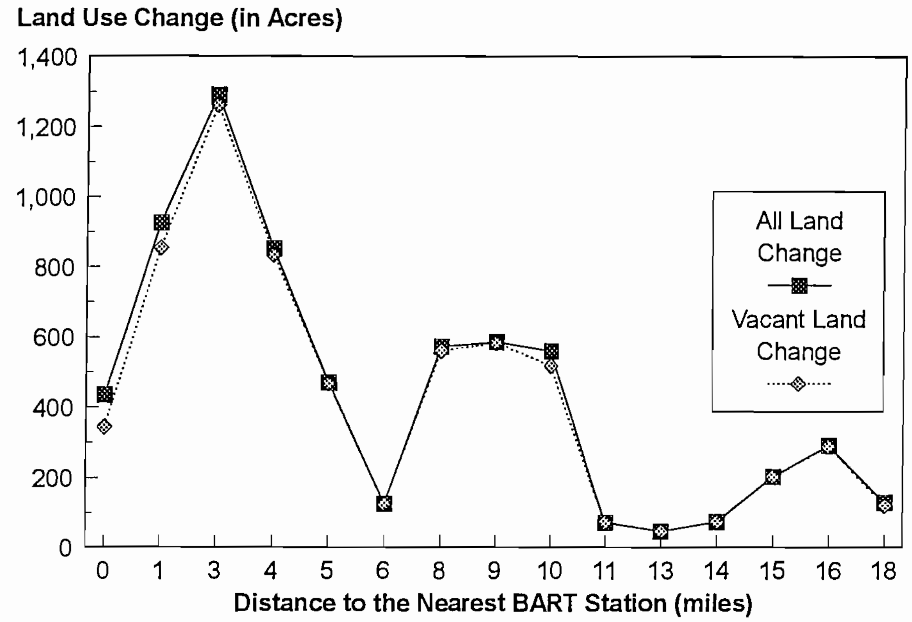
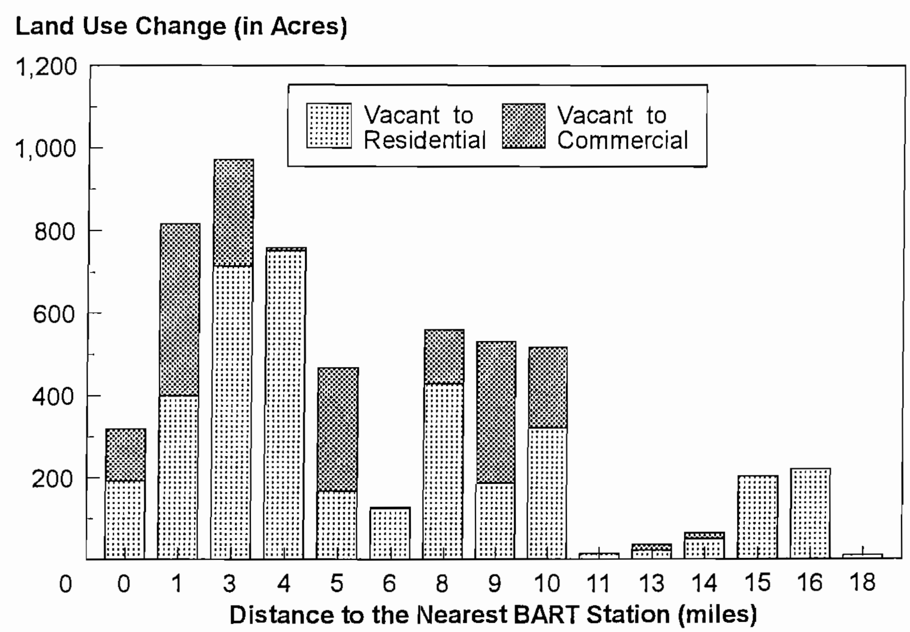


Figure 6.5b: Alameda County Vacant Land Use Changes as a Function of Distance to the Closest BART Station: 1985-90



of Chapter Five, relatively little land-use change occurred in the immediate areas surrounding Alameda County BART stations. Indeed, as Figure 6.5a shows, whether for all land or just vacant land, the pattern of land-use change in Alameda County between 1985 and 1990 followed a downward-sloping gradient extending from 3 to 18 miles around county BART stations.

Most land-use changes in Alameda County during this period involved the conversion of undeveloped land to residential or commercial uses. As Figure 6.5b shows, the mix of new residential vs. new commercial development did not seem to be a function of proximity to a BART station. Regardless of BART station proximity, the level of new residential development was about twice that of new commercial development. There was virtually no new commercial development on vacant sites ten or more miles from BART stations.

Recent Alameda County land-use changes have been even more concentrated around highway interchanges than around BART stations. As Figure 6.6 shows, almost all of the land-use changes which occurred in Alameda County between 1985 and 1990 occurred within two miles of a freeway interchange. This result is partially due to the fact that Alameda County is very well served by freeways, and that freeway interchanges are closely spaced.

A very different pattern emerges when land-use changes are compared according to distance from downtown Oakland (Figure 6.7a). Moving outward from downtown Oakland in 10-mile increments, very little land-use change or vacant land development occurred within the first 10-mile ring (mostly because of a lack of vacant and developable sites). About two-thirds of Alameda County land-use changes occurred in the 10-to-20-mile ring, with the remaining third occurring in the 20-to-30-mile ring. As Figure 6.7b shows, the new development that did occur within 10 miles of downtown Oakland was almost entirely residential. Beyond 10 miles, there was no clear pattern to the mix of residential vs. commercial development.

Contra Costa County: Confirming the findings reported in Chapter Five, proximity to a BART station did not seem to be an incentive for land-use change in Contra Costa County between 1985 and 1990. Indeed, as Figure 6.8a shows, very little vacant land development or redevelopment occurred within a mile of Contra Costa County BART stations between 1985 and 1990. Once beyond this radius, however, the pace of land-use change accelerated, with about half of the county's land-use change occurring within a 4- to 12-mile radius of BART stations. As in Alameda County, the mix between residential and commercial development was unrelated to BART proximity (Figure 6.8b).

Nor were 1985-90 land-use changes in Contra Costa County concentrated around freeway interchanges — in sharp contrast to Alameda County. Indeed, as Figure 6.9a shows, about 2/3 of all Contra Costa County land-use changes between 1985 and 1990 occurred four to ten miles distant from the closest freeway interchange. Those few land-use changes that occurred within two miles of a freeway

Figure 6.6a: Alameda County Land Use Changes as a Function of Distance to the Closest Freeway Interchange: 1985-90

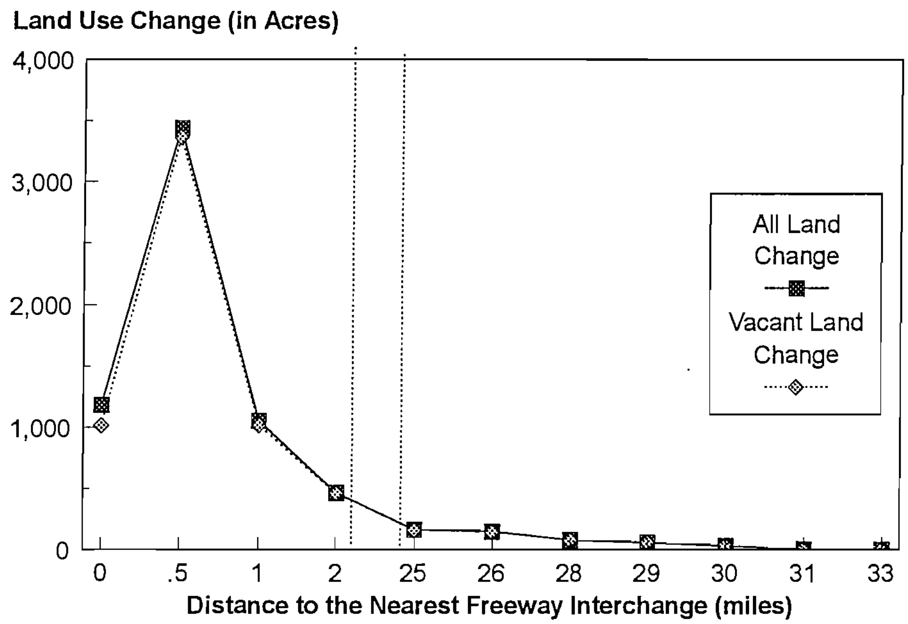


Figure 6.6b: Alameda County Vacant Land Use Changes as a Function of Distance to the Closest Freeway Interchange: 1985-90

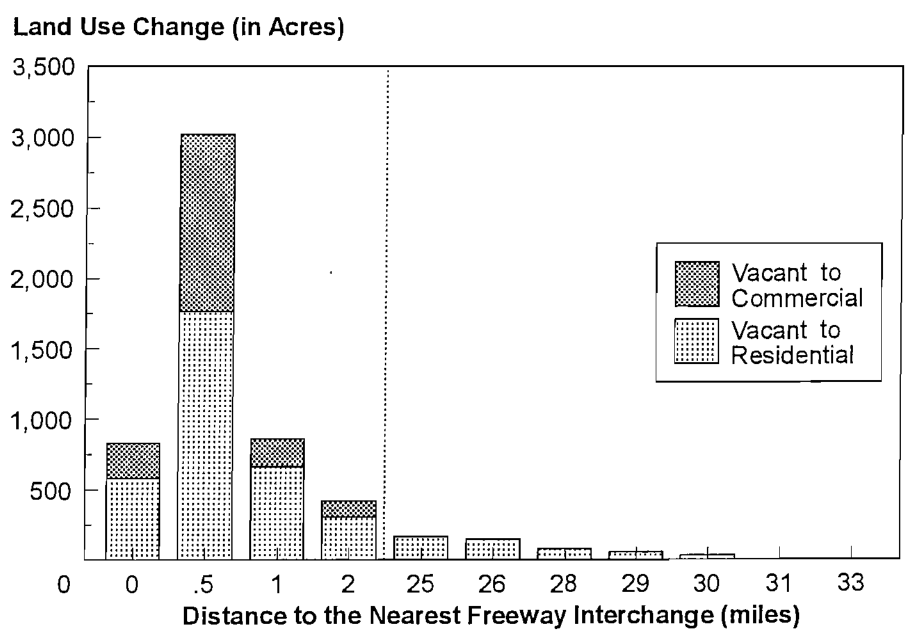


Figure 6.7a: Alameda County Land Use Changes as a Function of Distance to Downtown Oakland: 1985-90

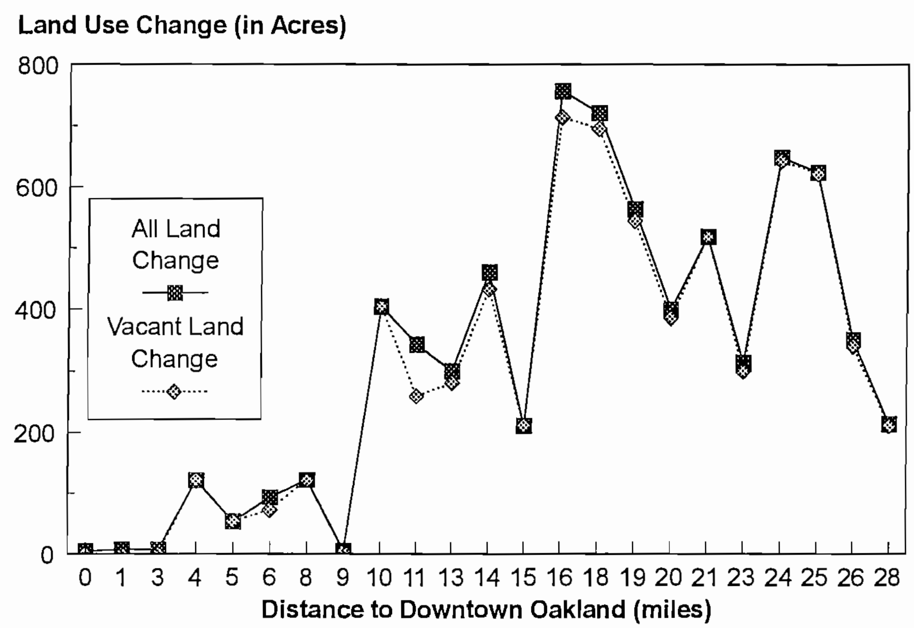


Figure 6.7b: Alameda County Vacant Land Use Changes as a Function of Distance to Downtown Oakland: 1985-90

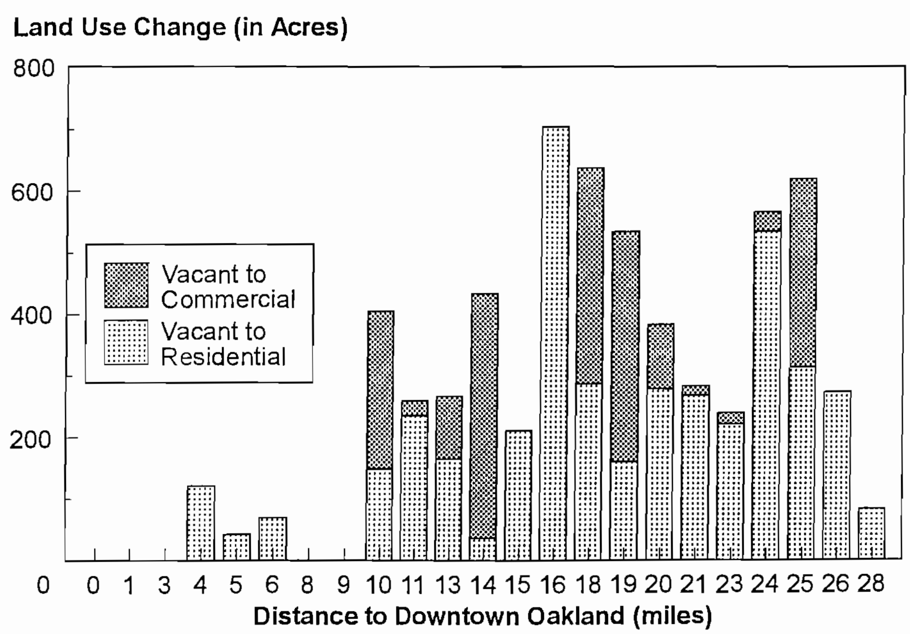


Figure 6.8a: Contra Costa County Land Use Changes as a Function of Distance to the Closest BART Station: 1985-90

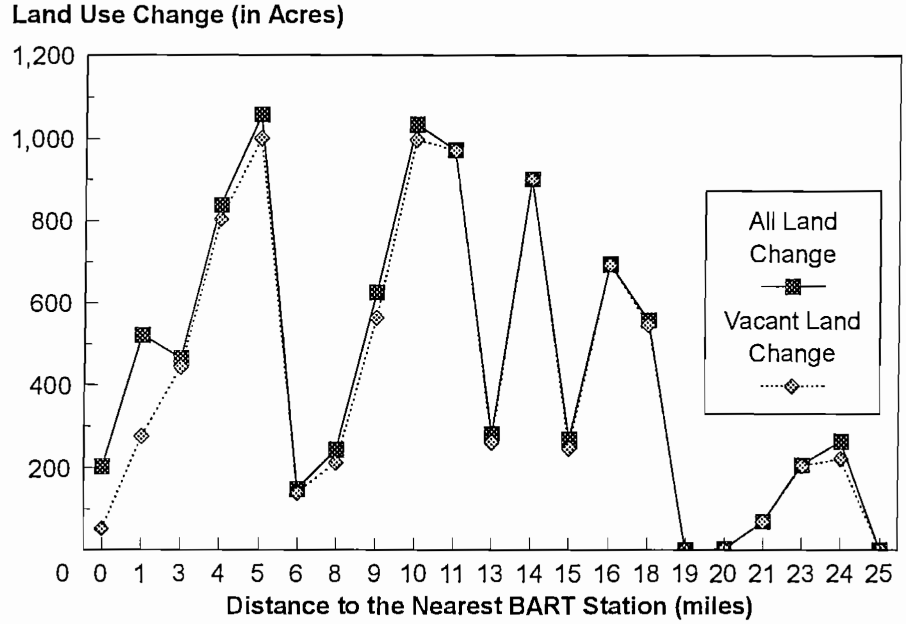


Figure 6.8b: Contra Costa County Vacant Land Use Changes as a Function of Distance to the Closest BART Station: 1985-90

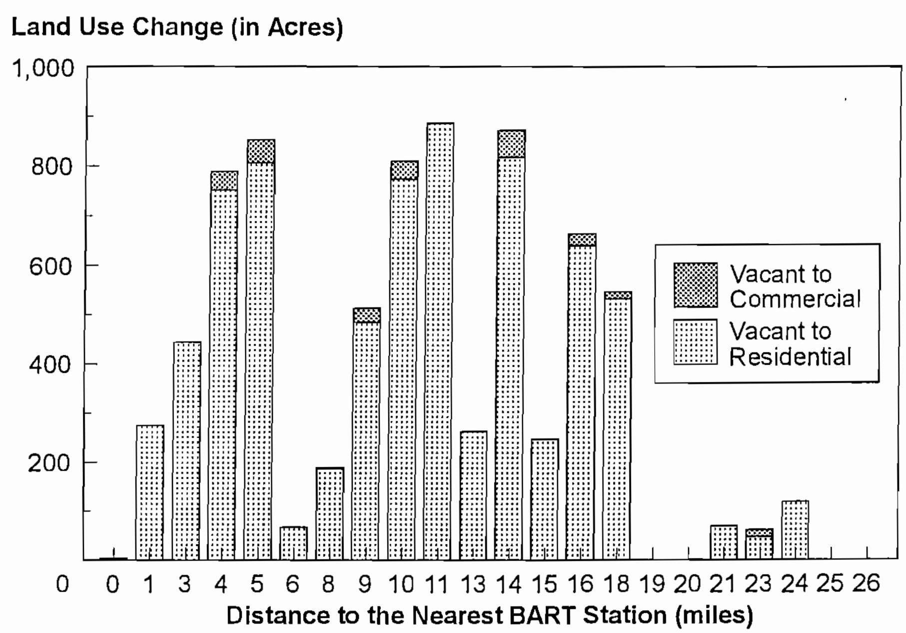


Figure 6.9a:
Contra Costa County Land Use Changes as a Function of Distance to the Closest Freeway Interchange: 1985-90

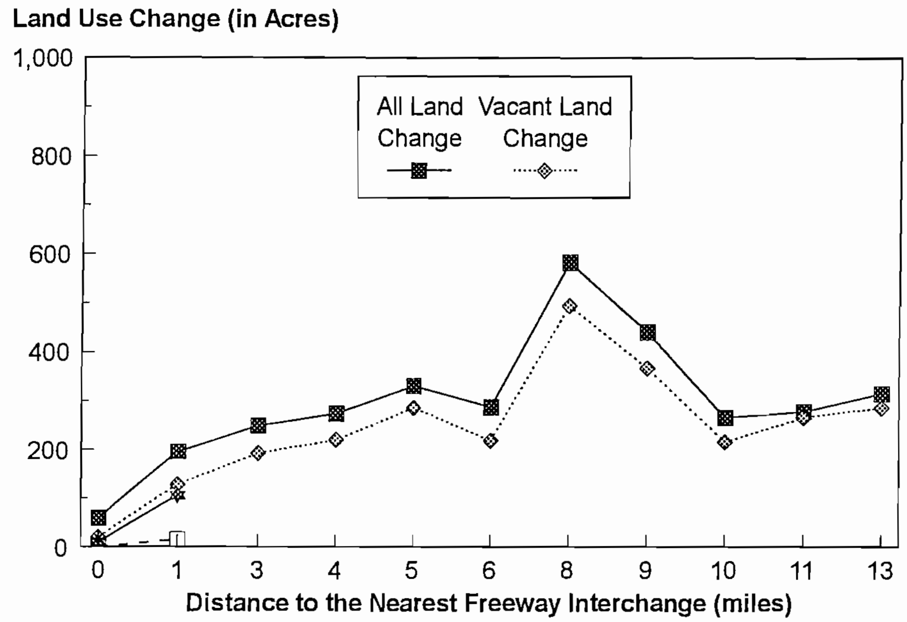
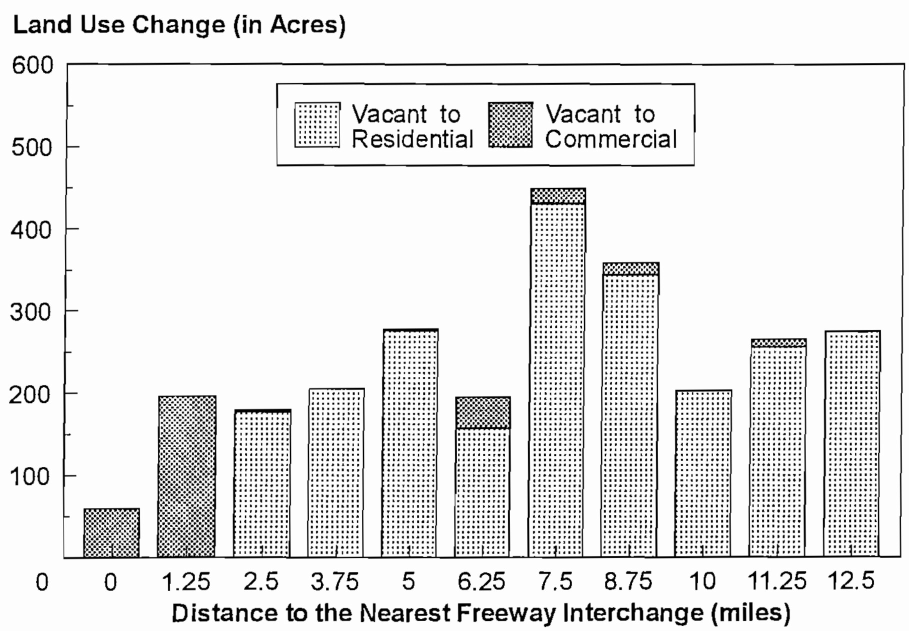


Figure 6.9b: Contra Costa County Vacant Land Use Changes as a Function of Distance to the Closest Freeway Interchange: 1985-90



tended overwhelmingly to involve new commercial development (Figure 6.9b). More distant land-use changes, by contrast, consisted almost entirely of new residential development.

The pattern of land-use changes in Contra Costa County between 1985 and 1990 was also unrelated to proximity to downtown Oakland (the closest point in Contra Costa County to downtown Oakland is six miles away). Moving outward from downtown Oakland in 10-mile rings, relatively little land-use change or vacant land development occurred within the first 10-mile ring (Figure 6.10a). About half of Contra Costa County land-use changes occurred in the 10-to-20-mile ring, with the remaining half occurring 25-35 miles from downtown Oakland. Finally, as Figure 6.10b shows, proximity to downtown Oakland had no effect on the mix of commercial and residential land development.

6.2. Model Specifications

The figures shown above *separately* consider the effects of different factors — including BART proximity — on metropolitan land-use change. To consider them together, or in combination, requires the use of multi-variate statistical models. Because we are modeling land-use changes as discrete, we will use the same types of logit models developed in Chapter Five.

Two types of logit models of land-use change are developed in the sections that follow: (i) *land-use change models*, in which the dependent variable measures the probability that a particular land-use polygon[20] of any initial use changed use during the study period; and (ii) *vacant land development models*, in which the dependent variable measures the probability that an initially vacant land-use polygon was developed to some other use. The number of observations in each vacant land model is weighted by site area (as represented by the size of each land-use polygon) so that the results are not dominated by changes to small sites.

Both types of models are binomial. This means that the dependent variable takes on only two values, a 1 indicating that a change of use occurred, or a 0, indicting that it did not. For each land-use polygon, we measured the *aerial* (or straight-line) distance from the polygon centroid to the closest BART station.[21] All else being equal, we would expect the coefficient of this variable, called *BART_ DIST*, to be negative. That is, we would expect the probability that a particular land-use polygon would change use or be developed should decline as distance to the nearest BART station increases.

Proximity to a BART station is but one of many determinants of land-use change. Twelve other variables were entered into the various models as explanatory factors. They include:

> 1. *City Population Change Between 1980 and 1985:* Every land-use polygon in the sample is located either in an incorporated city, or in unincorporated Alameda or Contra Costa County. All else being equal, one would expect that land-use polygons located in faster-growing cities to have a higher probability of being developed or changing use, than land-use polygons in slower-growing cities.[22] The independent variable *POPCHNG percent* measures the rate of population change between 1980 and 1985 for the particular city in which each land-use polygon is located. Data on city population changes were obtained

Figure 6.10a:
Contra Costa County Land Use Changes as a Function of Distance to Downtown Oakland

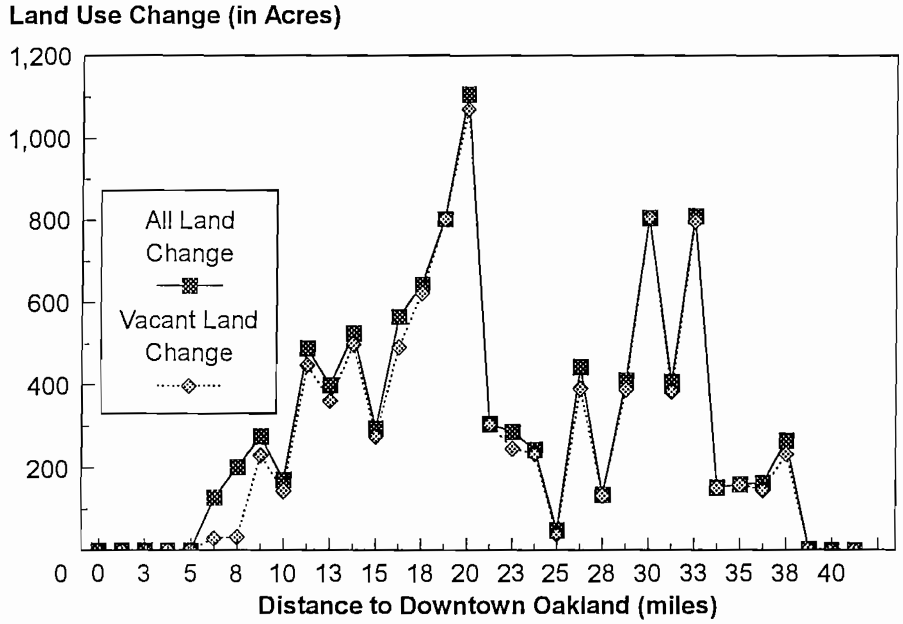
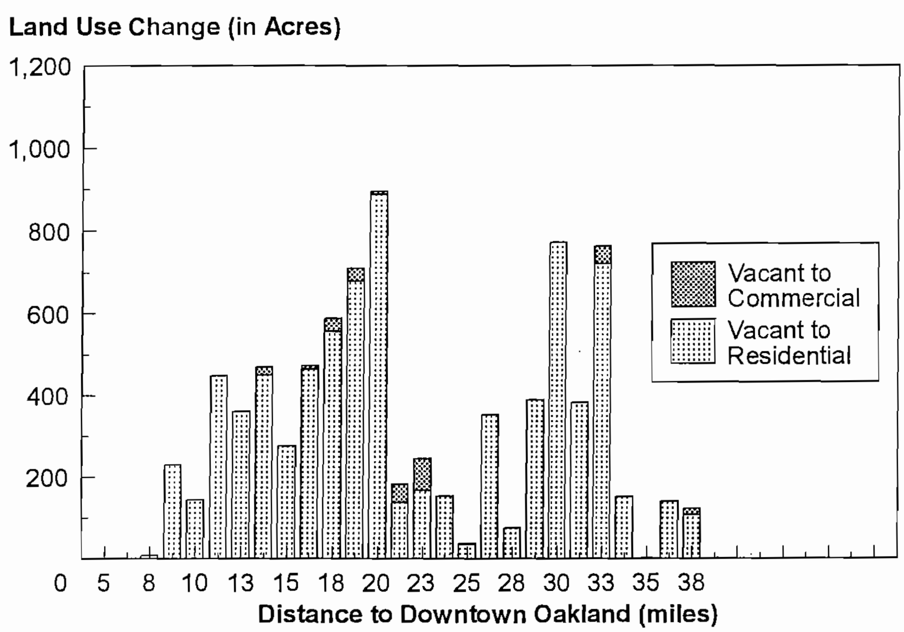


Figure 6.10b: Contra Costa County Vacant Land Use Changes as a Function of Distance to Downtown Oakland: 1985-90



from the Association of Bay Area Governments (ABAG). Following our hypothesis, above, we would expect *POPCHNG percent* to have a positive coefficient.

2. *City Employment Change Between 1980 and 1985:* Employment growth, like population growth, adds to the demand for developed land. The independent variable *EMPCHNG percent* measures the rate of total employment change between 1980 and 1985 for the particular city in which each land-use polygon is located. Data on city employment growth between 1980 and 1985 was obtained from ABAG. As with *POPCHNG percent*, we would expect *EMPCHNG percent* to have a positive coefficient.

3. *City Population-1985*: Population growth in the Bay Area over the past three decades has generally favored smaller suburban cities over larger urban ones. All else being equal, we would expect land-use polygons in larger cities to be less likely to either change land use or be developed than land-use polygons in larger cities. The independent variable *CITYPOP85* measures the population as of 1985 for the particular city in which each land-use polygon is located. The values for this variable were obtained from ABAG. Following our hypothesis above, we would expect *CITYPOP85* to have a negative coefficient.

4. *City Employment-1985*: How does the size of a city's economy affect the development of particular sites within that city. One can theorize that the size effect — if it exists at all — could be positive or negative. On the one hand, the agglomeration economies associated with larger employment centers should make nearby undeveloped sites more attractive, thereby increasing their probability of development. On the other hand, land prices in cities with a large employment base are likely to be higher than in cities with smaller economies. To the extent that employers are drawn to less expensive land, the relationship between the size of a particular city's employment base and the probability of a land-use polygon within that city being developed may well be negative.

A third perspective is empirical. Recent employment growth in the Bay Area has followed a different spatial pattern than population growth. Like population, employment has been suburbanizing. Unlike population growth, employment growth has also been concentrating — in so-called suburban activity centers. This suggests that there should be a generally positive relationship between the size of a particular city's employment base and the probability of a land-use polygon within that city being developed, or changing use. The independent variable *CITYEMP85* measures the employment base as of 1985 for the particular city in which each land-use polygon is located. As with *CITYPOP85*, the values for this variable were obtained from ABAG.

5. *Straight-Line Distance to the Nearest Highway Interchange*: Proximity to a highway interchange is commonly regarded a key determinant of development potential, at least among most private developers. To test the validity of this assumption, as well as to compare it to the effects of BART station proximity, we measured the aerial distance from the centroid of every land-use polygon to the closest freeway interchange. All else being equal, we would expect the coefficient of this variable, called *HWY_DIST*, to be negative. That is, we would expect the probability that a particular land-use polygon would change use or be developed should increase as its distance to the nearest highway interchange decreases.

6. *Straight-Line Distance to Oakland:* Traditional urban economics suggests that the demand for sites should be greatest near major city centers — for reasons of agglomeration and minimized transportation costs. More recent studies have indicated that other factors may be more important, and that proximity to a CBD may be less important.[23] To test the importance of CBD proximity, we measured the aerial distance from downtown Oakland (the major employment center for the Alameda-Contra Costa metropolitan area) to the centroid of every land-use polygon. Consistent with theory, we would expect the coefficient of this

variable, called *OAK_DIST*, to be negative. That is, we would expect the probability that a particular land-use polygon would change use or be developed would increase as its distance to downtown Oakland decreases.

7-8. *Initial Land Use:* The likelihood that a site will change land use or be developed may also depend on its initial use. Generally speaking, we would expect undeveloped sites to be more likely to change use than already-developed sites. Among already-developed land types, we hypothesize that lower-order uses (e.g, residential) are more likely to change to higher-order uses (e.g., commercial), than vice versa. To incorporate this effect into the model, we created two dummy variables: *INIT_USE-Undeveloped* designates undeveloped land, and is set equal to 1 if the initial land-use type is undeveloped, and to 0 if the initial use is developed. *INIT_USE-Residential* designates residential use: it is set equal to 1 if the initial land-use type is residential, and to 0 if the initial use is non-residential.

9-11. *Adjacent Land Uses*: All else being equal, we would expect site land uses to be strongly affected by the pattern of neighboring or adjacent uses. We would expect, for example, that a vacant site surrounded by residential uses would tend to be developed to residential use. The same would hold true for a vacant site surrounded by commercial uses; all else being equal, we would expect it to be developed in commercial use.

To measure this effect, we developed three index variables: *ADJ_Residential* measures the proportion of adjacent initial polygon land uses in residential use. *ADJ_Commercial* measures the proportion of adjacent initial polygon land uses in commercial uses. And *ADJ_Undeveloped* measures the proportion of adjacent polygon land uses not initially developed. All three variables vary between 0 and 1, depending on the mix of adjacent uses (higher values indicate a greater proportion of adjacent land uses of a particular type).

We have no single set of expectations regarding estimated parameter signs and values. For the binomial change models, we would expect that the probability of a polygon land-use change should increase with the proportion of adjacent land uses developed in higher-order uses. That is, we might expect the parameter signs associated with *ADJ_Residential* and *ADJ_Commercial* to be positive, and greater for *ADJ_Commercial* than for *ADJ_Residential.*

12. *Polygon Size:* Smaller sites are easier to develop, but larger sites tend to be more economical to develop. The variable *Polygon_Size* measures the size in square meters of each land-use polygon. It is included in the following logit models to hold constant the role of site size in determining patterns of land-use change and development.

6.3. Model Results

Overall Patterns of Land-Use Change

How well do these various factors explain patterns of land-use change in Alameda and Contra Costa Counties? Table 6.3 presents the results of binomial logit models of land-use change for Alameda and Contra Costa Counties between 1985 and 1990. The models reported in Table 6.3 consider all types of land uses, not just changes in the status of undeveloped land. The Alameda County model is based on 43,538 land-use polygons (of which 1,238 or 2.8 percent changed use between 1985 and 1990), while the Contra Costa County model is based on 42,153 land-use polygons (of which 1,438 or 3.4 percent changed use).

Table 6.3: Binomial Logit Model Results for All Land Use Polygon Changes: 1985-1990

Dependent Variable: 0: Unchanged land use - all sites
1: Changed land use - all sites

Independent Variables	Alameda County Coefficient	Alameda County t-stat	Contra Costa County Coefficient	Contra Costa County t-stat
Access Variables				
BART_DIST	-0.00003	34.74	0.000075	82.79
HWY_DIST	-0.00027	138.69	-0.00014	150.54
OAK_DIST	3.30E-04	54.99	-0.00003	24.96
City Variables				
CITYPOP85	-7.96E-05	17.26	-0.00001	12.50
CITYEMP85	9.97E-05	7.01	0.000045	55.17
POPCHG%	14.4286	73.55	1.2128	4.00
EMPCHG%	-2.1856	22.94	0.00359	0.00
Site Variables				
ADJ_Undeveloped	2.7649	153.76	2.3045	159.60
ADJ_Residential	1.4867	45.73	0.7819	17.58
ADJ_Commercial	1.3451	27.70	-0.2123	0.71
SITE_AREA	-8.48E-06	7.03	-6.30E-06	8.80
INIT_USE-Undeveloped	1.9157	169.42	0.2703	5.59
INIT_USE-Residential	-1.6683	47.33	-1.862	128.83
Constant	-6.7431	965.66	-4.5037	676.05
Observations	43,538		42,153	
Changed	**1,238**		**1,438**	
% predicted by the model	**85.0%**		**74.8%**	
Unchanged	42,300		40,715	
% predicted by the model	81.6%		69.4%	

Overall, the two models do a very good job of explaining land-use changes in both counties. The Alameda County model correctly predicts 85.0 percent of polygon land-use changes, while the Contra Costa model correctly predicts 74.8 percent. All of the coefficients in the Alameda County model and 11 of the coefficients in the Contra Costa County model were statistically significant; although, as we note below, not all were of the expected signs.

Alameda County: We consider the Alameda model results first. As expected, distance to a BART station and the probability that a particular land-use polygon changed use are negatively related, as are distance to a freeway interchange and the probability of land-use change. This means that sites near BART stations and freeway interchanges in Alameda County were more likely to change land use between 1985 and 1990 than more distant sites. The two coefficient estimates are hardly equal, however: for a given distance, sites near freeway interchanges were 10 times more likely to change use than sites near BART stations. Somewhat contrary to expectations, distance to downtown Oakland was found to be positively related to the probability of a land-use change.

Particular land-use polygons were less likely to change use if located in larger cities, or in cities with economies that grew during the previous five years. Conversely, particular sites were much more likely to change use if located in cities with a large jobs base in 1985, or in cities that had gained significant amounts of population. All else being equal, smaller land-use polygons were more likely to change use than larger ones.

All else being equal, undeveloped or vacant land-use polygons were more likely to change land uses between 1985 and 1990. Polygons already in residential use were less likely to change use — another expected result. Polygons surrounded by large amounts of undeveloped land were twice as likely to change land use between 1985 and 1990 as were polygons surrounded by residential uses or commercial uses. The positive coefficient signs for *ADJ_Residential* and *ADJ_Commercial* were expected; the positive sign for *ADJ_Undeveloped* was not. All else being equal, smaller land-use polygons were somewhat more likely to change land use than larger ones.

Contra Costa County: Sites near BART stations in Contra Costa County were *less likely to change land uses between 1985 and 1990* than more distant sites. This result differs markedly from that of Alameda County, where proximity to BART was a significant determinant of land-use change. In most other respects, the results of the Contra Costa land-use change model are comparable to those of Alameda. All else being equal, Contra Costa sites were more likely to change land use between 1985 and 1990 if located in a city with a large jobs base, in a city with an expanding population, or near a highway interchange. City employment growth (at least between 1980 and 1985) was not a significant predictor of land-use change — a somewhat curious result, and one that differs from the Alameda County case, above. Sites closer to downtown Oakland (that is, in the western part of Contra Costa County) were slightly more likely to change use than more distant sites. Sites were also more likely to change use if surrounded by undeveloped or residentially developed land. Sites surrounded by commercial uses were neither more likely or less likely to change land use. As in Alameda County, undeveloped sites were more likely to change land use than residentially developed sites.

Patterns of Vacant Land Development

Most of the land-use change reported for Alameda and Contra Costa Counties between 1985 and 1990 involved the development of previously undeveloped, or vacant, lands. Of the 1,238 land-use polygons that changed use in Alameda County between 1985 and 1990, 1,113 (or 89.9 percent) involved changes from an undeveloped use to a developed use. In Contra Costa County, the development of vacant sites accounted for 80.1 percent of site land-use changes between 1985 and 1990. To what extent are the determinants of undeveloped land-use change *different* from the determinants of land-use change in general? Table 6.4 summarizes the results of two binomial logit models of undeveloped land-use change for Alameda and Contra Costa Counties between 1985 and 1990. (Table 6.7 summarizes the results of similar models for developed land-use change). As noted above, the number of observations is weighted by polygon size to prevent smaller polygons from biasing the results.

Alameda County: The Alameda County model summarized in Table 6.4 correctly explains about two-thirds of the changes to vacant land-use polygons between 1985 and 1990. All of the included independent variables are statistically significant, and most are of the expected sign. Vacant sites in Alameda County were more likely to be developed if located in small but fast-growing cities, in cities with large initial jobs bases, or located close to a BART station or freeway interchange. As in the previous section, sites near freeway interchanges were much more likely to be developed than sites a similar distance from BART stations. Also, as in the previous section, proximity to downtown Oakland proved to be a disincentive to development, not an incentive. Vacant sites surrounded by undeveloped uses, residential uses, or commercial uses were more likely to be developed than sites surrounded by other uses, and smaller land-use polygons were more likely to be developed than larger ones.

Contra Costa County: In Contra Costa County, vacant sites near BART stations were *less likely to be developed between 1985 and 1990* than more distant sites (in Alameda County, by contrast, BART-accessible sites were more likely to be developed). Otherwise, the results of the Contra Costa model parallel those of Alameda County. New development in Contra Costa County favored smaller sites; sites near freeways; sites in small, fast-growing cities; and sites surrounded by residential, commercial, or undeveloped uses. Proximity to downtown Oakland did not affect the probability that a vacant site would be developed one way or another. Overall, the Contra Costa County model summarized in Table 6.4 correctly explains 63.6 percent of the changes to vacant land-use polygons between 1985 and 1990.

Patterns of New Residential Development

In terms of land area, most new development in California is residential development. Altogether, 57.4 percent of undeveloped lands in Alameda County which were developed between 1985 and 1990 were developed to residential use. In Contra Costa, residential development accounted for 86 percent of vacant land-use polygon development between 1985 and 1990. To what extent does proximity to BART station explain the likelihood that a vacant site in Alameda or Contra Costa County will be developed to residential use *as opposed to some other use?* Table 6.5 presents the results of two binomial logit models of residential land-use change for Alameda and Contra Costa Counties between 1985 and 1990.

Table 6: 4: Binomial Logit Model Results for Vacant Land Use Polygon Changes: 1985-1990

Dependent Variable:	0: Vacant sites only: no land use change 1: Vacant sites only: change to different use			
Independent Variables	**Alameda**		**Contra Costa**	
	Coefficient	t-stat	Coefficient	t-stat
Access Variables				
BART_DIST	-0.00004	34.13	0.000028	8.43
HWY_DIST	-0.00025	113.01	-0.00012	99.33
OAK_DIST	3.80E-04	58.27	0.000012	3.59
City Variables				
CITYPOP85	-8.48E-05	15.63	-0.00002	45.60
CITYEMP85	1.20E-04	7.65	0.000056	68.24
POPCHG%	14.9919	53.80	1.8473	7.72
EMPCHG%	-2.3332	17.83	0.015	0.03
Site Variables				
ADJ_Undeveloped	3.2394	145.58	5.9767	269.59
ADJ_Residential	2.287	76.25	4.3173	153.55
ADJ_Commercial	2.9139	69.39	5.4499	115.45
SITE_AREA	-7.81E-06	6.33	-8.11E-06	11.48
Constant	-5.546	381.05	-7.9488	437.76
Observations	12,478		15,973	
Changed	**1,113**		**1,154**	
% predicted by the model	**67.8%**		**65.9%**	
Unchanged	11,365		14,819	
% predicted by the model	72.5%		65.9%	

Alameda County: Transportation access in general, *and proximity to a BART station in particular, was not an incentive for residential development in Alameda County between 1985 and 1990.* All else being equal, vacant land-use polygons near BART stations or freeway interchanges were less likely to be developed in residential use than were more distant sites. Overall, the Alameda County model summarized in Table 6.5 correctly predicts 84.5 percent of vacant land-use polygon conversions to residential development between 1985 and 1990. All of the included independent variables are statistically significant. Vacant sites in Alameda County were more likely to be developed to residential use if located in large or fast-growing cities, or if in close proximity to downtown Oakland. Conversely, vacant sites in cities with large and/or rapidly growing employment bases were less likely to be developed to residential use. Not surprisingly, vacant sites surrounded by other undeveloped sites or by residential uses were more likely

Table 6.5: Binomial Logit Model Results for Vacant Land Use Polygons: Change to Residential Use: 1985-1990

Dependent Variable: 0: Vacant sites only: Non-residential land use change
1: Vacant sites only: change to residential use

Independent Variables	**Alameda** Coefficient	t-stat	**Contra Costa** Coefficient	t-stat
Access Variables				
BART_DIST	0.000199	94.68	0.000033	1.88
HWY_DIST	0.000565	48.43	-0.0001	10.96
OAK_DIST	-8.00E-04	32.52	0.000009518	0.36
City Variables				
CITYPOP85	5.10E-04	82.61	-0.00007	24.33
CITYEMP85	-8.00E-04	57.44	0.000018	0.79
POPCHG%	43.9257	42.19	-20.8288	29.95
EMPCHG%	-8.7296	26.44	1.1349	6.88
Site Variables				
ADJ_Undeveloped	3.5595	49.81	1.4554	6.41
ADJ_Residential	7.293	140.96	4.677	43.23
SITE_AREA	-1.04E-05	1.46	3.11E-05	3.72
Constant	-6.4044	87.79	5.5506	17.34
Observations	1,113		1,154	
Changed	**708**		**951**	
% predicted by the model	**84.6%**		**80.5%**	
Unchanged	405		203	
% predicted by the model	57.8%		48.8%	

to be developed in residential use than sites surrounded by non-residential uses. Larger vacant sites were less likely to be developed in residential use than into non-residential use.

Contra Costa County: All else being equal, vacant sites near Contra Costa County BART stations were *somewhat less likely to be developed to residential use* than more distant sites. Proximity to a freeway interchange, by contrast, had the opposite effect; the closer a site was to a freeway, the more likely it would be developed in residential use, but only very slightly. Overall, the Contra Costa County model summarized in Table 6.5 correctly predicts 79.2 percent of vacant land-use polygon conversions to residential development between 1985 and 1990. Residential development in Contra Costa County between 1985 and 1990 favored sites in smaller cities and/or slower-growing cities — exactly the opposite result as for Alameda County. Residential growth in Contra Costa County also favored sites in cities with faster-growing

Table 6.6: Binomial Logit Model Results for Vacant Land Use Polygons: Change to Commercial Use: 1985-1990

Dependent Variable:
0: Vacant sites only: Non-commercial land use change
1: Vacant sites only: change to commercial use

Independent Variables	**Alameda** Coefficient	t-stat	**Contra Costa** Coefficient	t-stat
Access Variables				
BART_DIST	-0.00018	73.87	-0.00008	3.24
HWY_DIST	-0.00055	45.74	0.000029	0.29
OAK_DIST	1.16E-03	41.99	0.000054	2.86
City Variables				
CITYPOP85	-5.00E-04	63.78	0.000148	5.37
CITYEMP85	9.50E-04	50.15	0.000051	1.35
POPCHG%	-40.4027	23.49	53.8785	11.49
EMPCHG%	8.913	17.90	-1.8787	3.01
Site Variables				
ADJ_Undeveloped	3.1171	34.55	5.8692	17.32
ADJ_Nonresidential	6.453	114.04	6.2034	13.53
SITE_AREA	1.05E-05	1.47	-1.53E-05	0.60
Constant	-2.6867	13.54	-26.3825	20.28
Observations	1,113		1,154	
Changed	**344**		**55**	
% predicted by the model	**71.5%**		**50.9%**	
Unchanged	769		1,099	
% predicted by the model	72.7%		92.7%	

economies, and, somewhat surprisingly, cities which were closer to downtown Oakland. All else being equal, larger vacant sites were more likely to be developed to residential use than smaller sites — an understandable result, but one which is nonetheless at odds with previous model results which demonstrate a preference for smaller sites.

Patterns of Commercial and Industrial Development

Commercial development patterns are generally more difficult to predict than residential development patterns, so it is not surprising that the two models of vacant-land-to-commercial-development summarized in Table 6.6 are less reliable than their residential counterparts. Three hundred forty-four vacant land-use polygons in Alameda County were developed in commercial or industrial use between 1985 and 1990; the logit model summarized in Table 6.6 correctly predicts 70.9 percent of those changes.

The same model performs less well in Contra Costa County, correctly explaining only 56.4 percent of vacant-to-commercial land-use changes. As we note below, the two models differ in more than just predictive accuracy. In both cases, the number of observations were weighted by polygon size to reduce potential estimating bias.

Alameda County: Easy access to BART and to freeways was a significant determinant of commercial development patterns in Alameda County between 1985 and 1990. *All else being equal, vacant land-use polygons near BART stations and freeway interchanges were much more likely to be developed in commercial or industrial use than more distant sites.* All else being equal, vacant sites in Alameda County were more likely to be developed in commercial use if located in cities gaining jobs, or with large numbers of jobs; and less likely to be developed if located in cities gaining population, or with large numbers of residents. Somewhat surprisingly, vacant sites closer to downtown Oakland were less likely to be commercially developed. All else being equal, larger sites were more likely to be developed to commercial use than smaller sites.

Contra Costa County: All else being equal, vacant sites near Contra Costa County BART stations were *far less likely to be developed in commercial or industrial use* than more distant sites. Freeway access, by contrast, had a positive effect on the likelihood that a vacant site would be commercially developed. New commercial development in Contra Costa County between 1985 and 1990 followed population growth but not employment growth. New commercial development in Contra Costa County between 1985 and 1990 favored sites in cities with large populations but not large economies. It also favored smaller sites that were closer to downtown Oakland, the region's historical employment center.

Patterns of Redevelopment

With so much undeveloped land still available in Alameda and Contra Costa Counties, redevelopment is relatively infrequent. But it is not unknown. Altogether, only 238 acres of developed land in Alameda County, and 779 acres of developed land in Contra Costa County, were *redeveloped* into different uses between 1985 and 1990. Somewhat surprisingly, most redevelopment was from a higher-order use (e.g., industrial or commercial use) to a lower-order use (e.g., residential).[24] In Alameda County, for example, 139 acres of land were redeveloped from higher-order commercial or industrial uses to lower-order residential or public uses. By contrast, only 37 acres were redeveloped "upward" from residential to commercial or industrial uses.[25] A similar pattern was evident in Contra Costa County, where 322 acres were redeveloped "downward" as compared with only 27 acres redeveloped "upward."

What role, if any, does BART access play in shaping redevelopment patterns at the metropolitan scale? To answer this question, we developed an ordinal (binomial) logit model of redevelopment activity in Alameda and Contra Costa Counties between 1985 and 1990. Model results are shown in Table 6.7. Two types of changes were considered: (i) lower-order to higher-order land-use changes (e.g., residential

Table 6.7: Ordinal Logit Model Results for Redeveloped Land Use Polygons: 1985-1990

Dependent Variable:	0: Redeveloped to a lower-order land use 1: Redeveloped to a higher-order land use			
Independent Variables	**Alameda County**		**Contra Costa**	
	Coefficient	t-stat	Coefficient	t-stat
Access Variables				
BART_DIST	-0.0006	4.09	-0.00119	2.12
HWY_DIST	-0.00011	0.03	-0.00283	1.00
OAK_DIST	4.34E-03	4.50	0.00014	0.25
City Variables				
CITYPOP85	-1.70E-03	6.44	-0.00029	3.40
CITYEMP85	3.04E-03	8.00	0.000483	2.23
POPCHG%	-257.9	6.94	-206.1	3.04
EMPCHG%	67.804	7.90	60.049	3.32
Site Variables				
ADJ_Residential	7.026	13.35	11.322	3.75
ADJ_Nonresidential	0.4539	0.04	9.408	2.53
SITE_AREA	2.40E-05	0.00	4.30E-04	0.76
Constant	-7.5087	6.36	-0.3916	0.00
Observations	123		275	
Higher-order changes	22		5	
Lower order changesOrder	101		270	
% predicted by the model	88.9%		92.1%	

to commercial changes) which were coded to a value of 1; and (ii) higher-order to lower-order land-use changes (e.g., commercial to residential changes) which were coded to a value of 0. Altogether, there were 22 higher-order land-use changes, and 101 lower-order land-use changes in Alameda County between 1985 and 1990. In neighboring Contra Costa County, there were only higher-order land-use changes between 1985 and 1990, as compared with 270 lower-order land-use changes.

Although they are based on a small number of observations, overall the models explain redevelopment patterns in the two counties fairly well: the Alameda and Contra Costa models explain 87.8 percent and 92.7 percent, respectively, of redevelopment land-use changes between 1985 and 1990. Proximity to BART *(BART_DIST)* was a significant predictor of lower- to higher-order land-use changes in both counties. All else being equal, residential sites nearer BART stations were more likely to be redeveloped to commercial and industrial uses than more distant residential sites. In neither county was distance to the nearest freeway interchange a significant predictor of higher-order or lower-order redevelopment activity. In Alameda County, proximity to downtown Oakland was a significant predictor of lower-to-higher order land-use changes.

In both counties, city size and land-use change order were inversely related. This means that lower-order land-use changes dominated in larger cities and/or that higher-order land-use changes dominated in smaller cities. City population change and land-use change order were also inversely related. The size of each city's jobs base and the direction of job change were positively related to land-use change order. Higher-order redevelopment was more common in cities with large and growing jobs bases, while lower-order redevelopment predominated in cities with small or declining jobs bases.

All else being equal, redevelopment sites in Alameda County surrounded by residential uses tended to change to higher-order uses. In Contra Costa County, sites surrounded by either residential or commercial uses tended to change to higher-order uses. In neither county was initial site area (*POLYGON_SIZE*) a significant determinant of redevelopment activity.

6.4. Summary

The results of this chapter stand in marked contrast to those of Chapter Five. Whereas proximity to a BART station was found to have no effect on land-use changes near the stations themselves, the same measure consistently affects patterns of land-use change at the county scale. The direction of this effect, however, seems to vary by county.

All else being equal, the closer a particular site in Alameda county was to a BART station, the more likely it was to change land use, be developed to commercial use, or be redeveloped between 1985 and 1990. (Proximity to BART had no effect on patterns of new residential development in Alameda County.)

In Contra Costa County, by contrast, sites closer to BART stations were generally less likely to change use or be developed than more distant sites. The effect of BART proximity on Contra Costa County land-use changes did, however, differ by land use: sites near Contra Costa BART stations were more likely to be redeveloped or developed to commercial uses than more distant sites, but less likely to be developed or redeveloped into residential use.

CHAPTER SEVEN: Summary, Conclusions, and Policy Implications

7.1. Summary of Findings

The fundamental question underlying this research is whether urban rail transit investments affect nearby property values and land uses. The answer to this question, at least for transit systems in California, is *yes*, but not consistently, not by very much, and not always in the ways people expect. Among the specific findings of this research:

1. Proximity to rail mass transit *is* capitalized into home prices. Among 1990 Alameda County home sales, the price premium for single-family homes associated with (street) distance to the nearest BART station was $2.39 per meter. The 1990 home sales price premium associated with distance to the nearest BART station in Contra Costa County was $1.96 per meter.

   This capitalization effect is not universal, however. It depends on many things, quality of service first and foremost. Regional systems like BART, which provide reliable, frequent, and speedy service, and which serve large market areas, are more likely to generate significant capitalization effects. Among California urban rail transit systems, the San Diego Trolley also falls in this category. By contrast, systems which provide limited service, serve a limited market, operate at slower speeds, or do not help reduce freeway congestion are unlikely to generate significant capitalization benefits. CalTrain, and light-rail systems in San Jose and Sacramento, fall into this category.
2. Accessibility to rail transit *is not* consistently capitalized into commercial property values. Measured just on the basis of price-per-square-foot of lot area, retail, office, and industrial properties in Alameda County near BART stations did sell at a price premium between 1988 and 1994. Measured in constant-quality terms, however — to control for differences in lot and building size — Alameda, Contra Costa, and San Diego office, retail, and industrial properties did not sell at a premium between 1988 and 1994 compared to more distant but otherwise similar buildings.
3. Although there has been a significant amount of land-use change near BART stations since the system was first constructed, station proximity by itself does not seem to have a largan effect on nearby land-use patterns. Various statistical models were developed to separate the effect of station proximity from other factors that affect station-area residential and/or commercial land-use changes. The models were tested using data on land-use changes at nine representative BART stations. In none of the models tested — those involving all land-use changes, those limited just to the development of vacant sites, or those involving specific types of vacant land changes — was proximity to a BART station found to be a significant determinant of land-use change.
4. The same result held true for land-use changes at four (representative) San Diego Trolley stations between 1980 and 1994: proximity to a Trolley station was not found to be a significant determinant of vacant or developed land-use change.
5. A more mixed result emerges if one looks at land-use changes at the county or metropolitan scale. The closer a vacant site in Alameda County was to a BART station, the more likely it was to be developed in commercial or industrial use between 1985 and 1990. The opposite was true in Contra Costa County, where, all else being equal, vacant sites near BART station were less

likely to be developed into commercial or industrial uses between 1985 and 1990. In both counties, vacant sites near BART stations were less likely to be developed to residential use — in the case of Contra Costa County, far less likely.

Proximity to a BART station does appear to have a positive influence on redevelopment activity, however. All else being equal, residential sites *near BART stations* were far more likely to be redeveloped to commercial or industrial uses than more distant residential sites.

7.2. Explaining the Findings

Taken together, these results seem to contradict what has become today's conventional wisdom regarding the relationships between transit facilities, property values, and land-use patterns. The conventional wisdom is that commercial properties more than residential properties benefit from proximity to rapid transit stations with respect to sale prices and property values. This research suggests the opposite is true: that the accessibility advantages associated with proximity to a transit station tend to be capitalized into residential property values, but not necessarily into commercial ones.

A second aspect of today's conventional wisdom is that transit investments can encourage beneficial land-use changes at or near stations. Beneficial in this context is usually taken to mean greater development activity (thereby reducing development pressures in less transit-accessible locations), or greater densities (thereby substituting pedestrian and transit travel for auto travel). This research, although based on land-use changes at a relatively small number of stations, suggests that transit investments have very little impact on nearby land-use patterns.

We offer four possible explanations for these contradictions. The first two explanations are critiques of the models and data used. The second two explanations address issues of policy.

The Wrong Models, Mis-Used, and Based on Incomplete Data

First, one might argue that the various statistical models from which these results are drawn are incomplete, incorporate poor measurements, or are otherwise wrongly specified. This argument may have some applicability to the models of commercial property values presented in Chapter Four; those models are incomplete. With respect to the residential value and land-use change results presented in Chapters Three, Five, and Six, the model results are widely consistent with the results of other, somewhat less rigorous approaches.

Second, one might argue that these results are based on limited samples. The residential property value analysis presented in Chapter Three, for example, is limited to residential sales for a single year — 1990. Conceivably, a multi-year analysis might produce different results. The commercial property value data presented in Chapter Four does cover multiple years, but excludes commercial properties in San Francisco. Including downtown San Francisco properties, one could argue, might produce very different results. The station area land-use change analysis presented in Chapter Five was limited to nine BART and four San Diego Trolley stations. Although we strove to make the 13 stations representative of their broader systems, one could argue that they are not, and that the results would have been different had one looked at all stations. Finally, one might argue that the five-year period analyzed in Chapter Six is simply too brief a period within which to identify long-term county or regional land-use changes. Although all of these arguments have some merit, the fact remains that for the time periods and locations analyzed, the model results are consistent and robust.

An Absence of Supportive Land-Use Policies

A third explanation is more compelling. It is that the land use and commercial property value impacts of BART and the San Diego Trolley would have been greater (than what was observed) if the development of those systems had been accompanied by supportive land use and development policies. The assumption behind this explanation is that transit investments alone, in the absence of other supportive investments and public policies, are insufficient to significantly affect land-use patterns and values.

While this explanation may ring true, it begs the larger question of what exactly constitutes *supportive* land-use policies. Transit-supportive land-use policies are like a two-sided equation. One side of the equation includes incentive policies designed to promote certain types of development near transit stations. Incentive policies may include higher-use or higher-density zoning, other specific public infrastructure investments, certain types of regulatory relief, joint development initiatives, a higher level of urban design quality, and perhaps even subsidies to particular uses. With the exception of two or three stations (Embarcadero, Oakland-City Center, Walnut Creek), the development of BART occurred in the near total absence of locally supportive land-use policies. Indeed, at a number of BART station areas, the explicit local response to BART was to prevent the development of different uses or higher densities. The construction of the San Diego Trolley system, likewise, was not accompanied by any significant local land-use policy changes — except in downtown San Diego.

The other side of the supportive land-use policy equation involves trying to prevent appropriate uses which would otherwise locate near transit stations from "leaking out" to other areas. Practically speaking, this usually involves "down-zoning" suburban locations. A few cities have tried this with partial success. San Francisco's Downtown Plan, for example, has successfully prevented commercial and office uses from encroaching on residential neighborhoods; it has been less successful at focusing such development into the areas adjacent to transit stations. Other cities such as Oakland and El Cerrito have tried to restrict the development of higher-density housing to transit corridors. The essential problem with these types of policies is that they require a tremendous (and heretofore unattainable) amount of inter-jurisdictional coordination. In the absence of such coordination, California cities have fallen into the practice of competing with each other for property-tax-generating commercial developments. Thus, policies designed to re-direct low-density development into higher-density transit corridors in City A usually have the effect of diverting growth from City A to City B, or into unincorporated areas.

Related to this is the fact that transit rights-of-way and stations are often located in areas which are not particularly amenable to development or redevelopment. San Diego's North-South Trolley line, for example, is wedged between a freeway, naval facilities, and active industrial areas. Most of the development which has occurred in San Diego over the last 15 years has occurred in an entirely different area. BART suffers from a similar problem over much of its right-of- way. Large portions of the Richmond-Fremont line, for example, run through older industrial areas where redevelopment is neither likely nor immediately feasible.

The Weakening Transit/Land-Use Connection

A final explanation is that transit investments may no longer have the ability to substantially impact urban land-use forms or land prices. This is the explanation that is most consistent with the findings of this research. It is also an explanation that many transit advocates find difficult to accept. They point to studies documenting the crucial role of rail transit investments guiding the early 20th century development of Boston, Chicago, Oakland, and even Los Angeles. Why, they ask, should rail transit have served to organize urban development patterns 70 or 80 years ago, but not have that function now?

The answer to this question is two-fold. First, a far smaller percentage of today's urban residents rely on transit than was the case even 40 years ago. With most residents preferring to travel via private auto — and with the private auto being a superior mode for most non-work trips — the attraction of living or working near transit (except as a means for coping with street congestion) has steadily declined. Second, what is sometimes forgotten about the electric trolley systems of the early 20th century is that they were privately developed for the express purpose of bringing potential suburbanites to new subdivisions. They were not built for the purpose of guiding redevelopment efforts or promoting infill development. Nor were they planned and constructed by the public sector. The process of land acquisition, subdivision, site planning, and extending transit lines occurred simultaneously and usually under the auspices of a single business entity — the private land developer. Instead of local development policies being shaped to serve transit (as is now being suggested), transit extensions were planned in order to facilitate speculative development.

7.3. Policy Implications

These findings lead to a number of significant policy conclusions. The first is that it may be possible to widen transit's local funding base through appropriately designed benefit assessment districts. We estimate, for example, that a yearly benefit-assessment fee of $50 applied to all single-family homes within a one-mile radius of a BART station could raise as much as $4 million per year.[26] The key words here are *appropriately designed*. This means conducting empirical research into the nature and extent of any transit capitalization effect before designating district boundaries. As in Sacramento or San Jose, some systems do not generate capitalized benefits. In other places (e.g., the East Bay), the benefits of transit service are capitalized into certain types of properties but not others. Imposing a local or downtown transit benefit assessment district when no real benefit is conferred is the same thing as imposing a tax. While such mechanisms may generate additional revenue in the short run, in the long run they have the potential to reduce property values and stifle new development activity.

A second policy conclusion is that, by themselves, new transit investments, no matter how well designed or planned, are unlikely to trigger significant changes to nearby land-use patterns. The evidence does not warrant counting increased development activity, more appropriate development forms, and/or higher land values as benefits to be associated with new transit investments. Nor should local land-use planners view transit investments as likely catalysts for their redevelopment efforts. In some locations, and during some periods, transit facilities have served to encourage nearby development. The more general finding, however, is that transit investments have been largely irrelevant to nearby land-use patterns and changes. This suggests that the development of transit villages will require sizeable private investments, a long-term commitment to planning, and additional public infrastructure over and above the transit facilities themselves. The availability of transit service is one of the amenities that draw residents and employers to locate in a particular neighborhood. No longer, however, is it the glue that binds cities together.

Appendix A: Regression Analysis of 1987 Single-Family Home Prices in Alameda and San Diego Counties

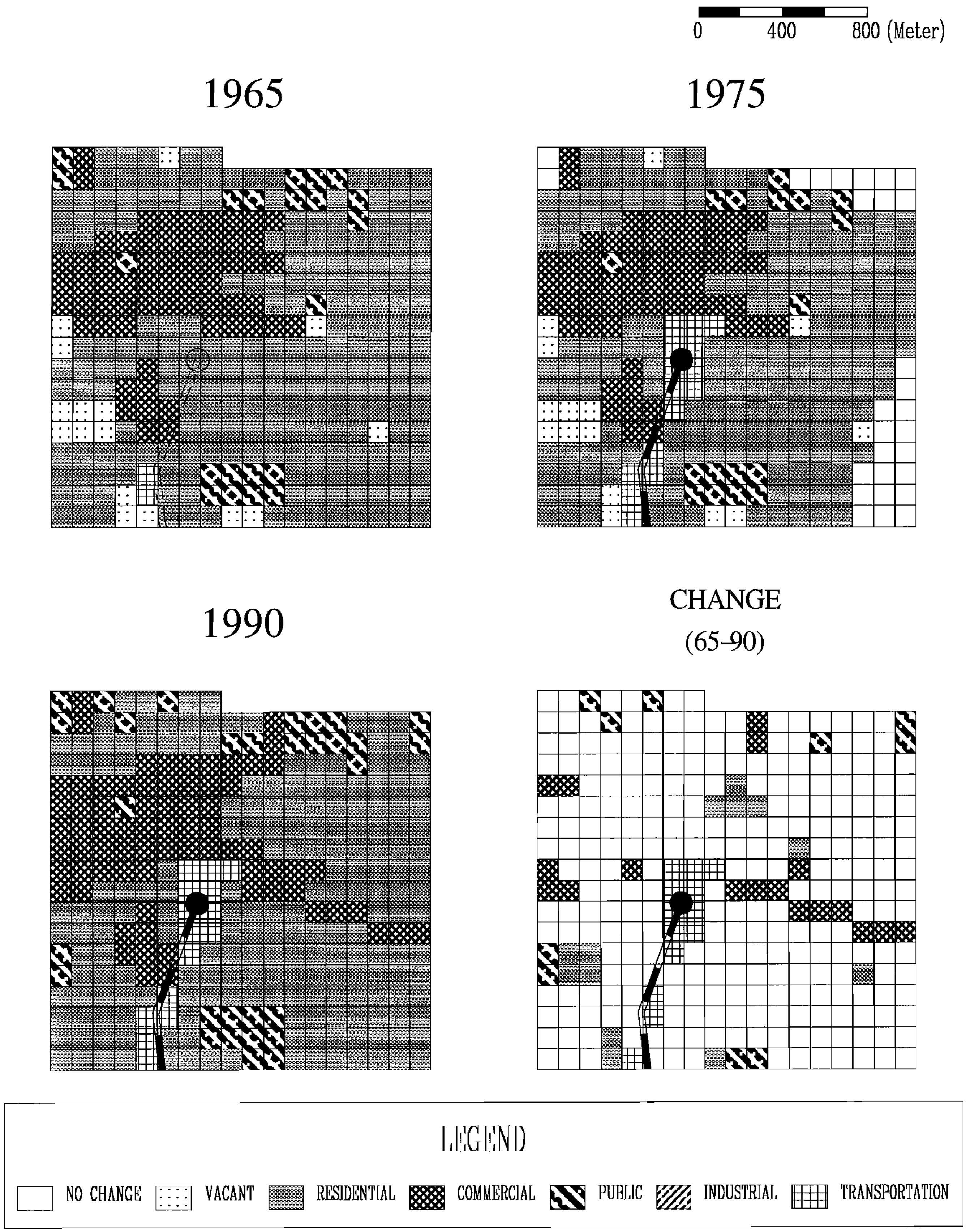
Appendix A: Regression Analysis of 1987 Single-Family Home Prices in Alameda and San Diego Counties (Compared to 1990 Results)

Dependent Variable: SALEPRICE

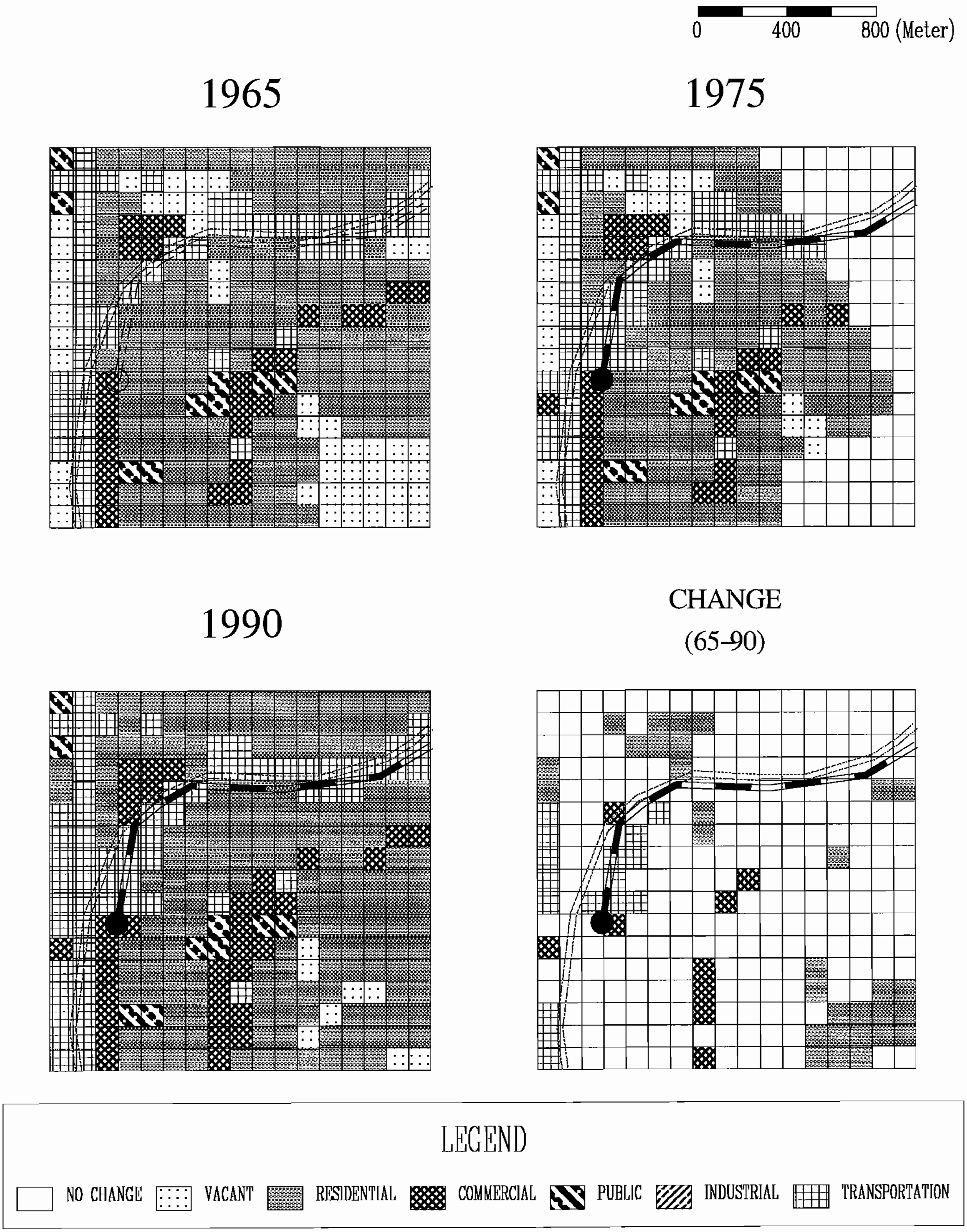
	Alameda County				San Diego County			
	1990 Sample		1987 Sample		1990 Sample		1987 Sample	
	Coefficient	t - stat	Coefficient	t - stat	Coefficient	t - stat	Coefficient	t - stat
Home Characteristics:								
SQFT	110.62	27.48	70.12	30.69	99.25	23.97	84.04	30.01
LOTSIZE	1.81	5.79	0.09	2.82	0.65	7.89	0.17	4.44
BATHS	3,768.88	1.23	6,430.22	3.14	5,099.49	1.31	8,136.43	3.06
AGE	91.63	1.00	417.28	7.04	271.00	1.93	379.08	3.98
BEDRMS	-5,523.37	-2.20	995.55	-0.68	-17,590.02	-6.86	-13,323.33	-7.24
Neighborhood Characteristics:								
MEDINCOM	2.10	12.02	2.18	18.64	4.53	21.36	1.98	13.90
PctWHITE	-	-1.62	30,871.84	1.73	-1,111.08	-1.68	39,949.32	0.87
PctASIAN	-	-2.21	-1,092.07	-0.06	-2,405.26	-3.07	-28,615.64	-0.60
PctBLACK	-	-2.66	-14,393.70	-0.74	-1,419.27	-1.54	40,647.13	0.80
PctHISPN	-	-4.14	-	-6.47	-494.09	-1.25	-11,453.46	-0.39
PctOWNER	-57,769.56	-4.92	51,009.74	-6.33	-1,619.40	-11.97	-91,426.06	-10.25
Locational Characteristics:								
HWYDIST	2.80	2.30	3.90	5.22	-0.84	-2.46	-0.09	-0.24
TRANDIST	-2.29	-10.50	-1.32	-9.02	0.17	2.36	-0.08	1.28
HWYADJ	-108.43	-0.03	4,094.24	-2.03	-2,631.09	-0.47	-4,815.82	-1.16
TRANADJ	5,240.62	0.81	5,499.41	1.56	-5,265.95	-0.39	1,917.84	0.2
CONSTANT	182,376.87	2.23	-35,151.34	-1.71	109,724.56	1.61	-24,811.70	-0.53
R -squared	0.80		0.73		0.73		0.67	
Observations	1131		2242		1128		1501	

Appendix B: Dominant Land Uses Around Nine BART Stations: 1965, 1975, 1990

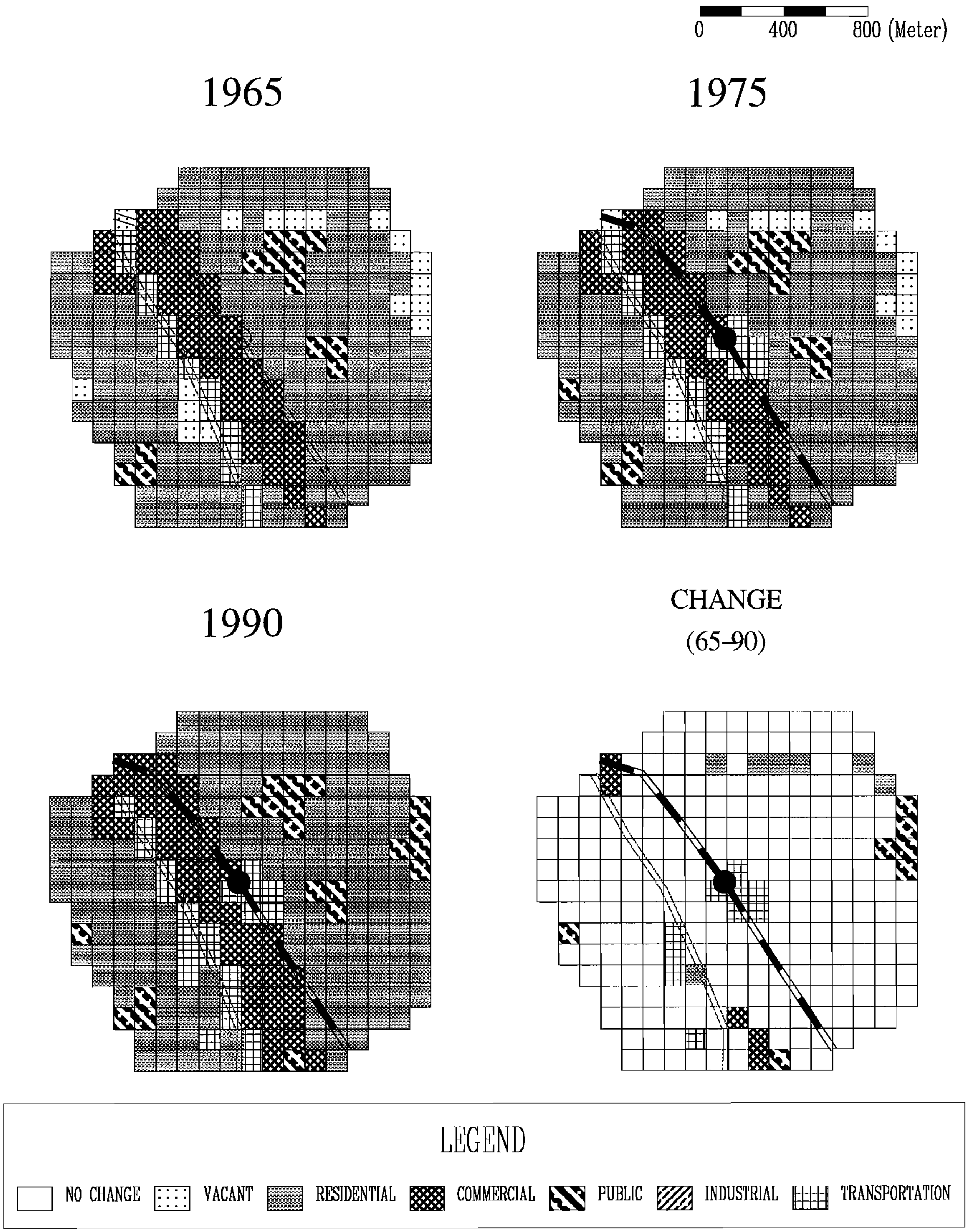
Concord Bart Station Area



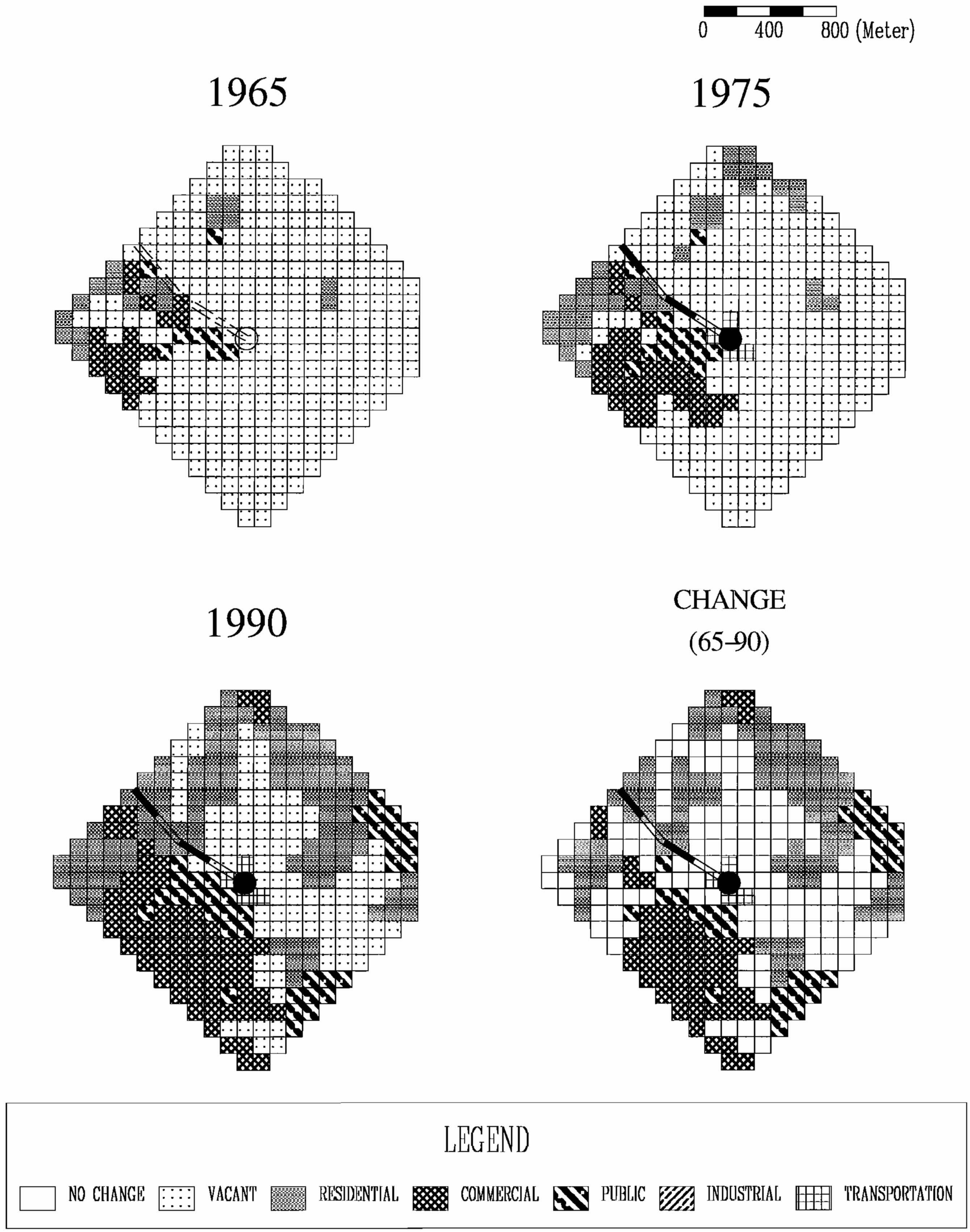
Daly City Bart Station Area

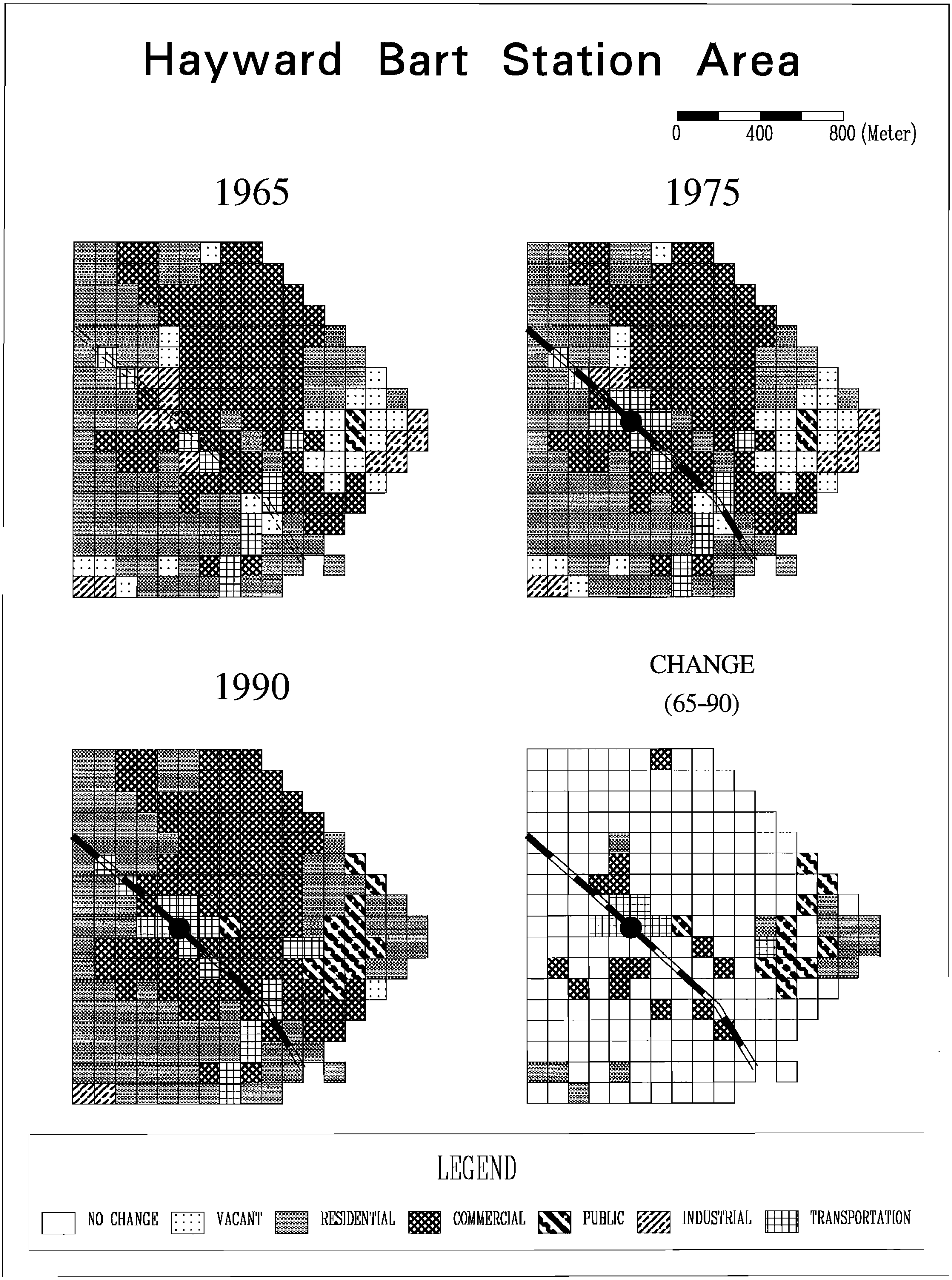


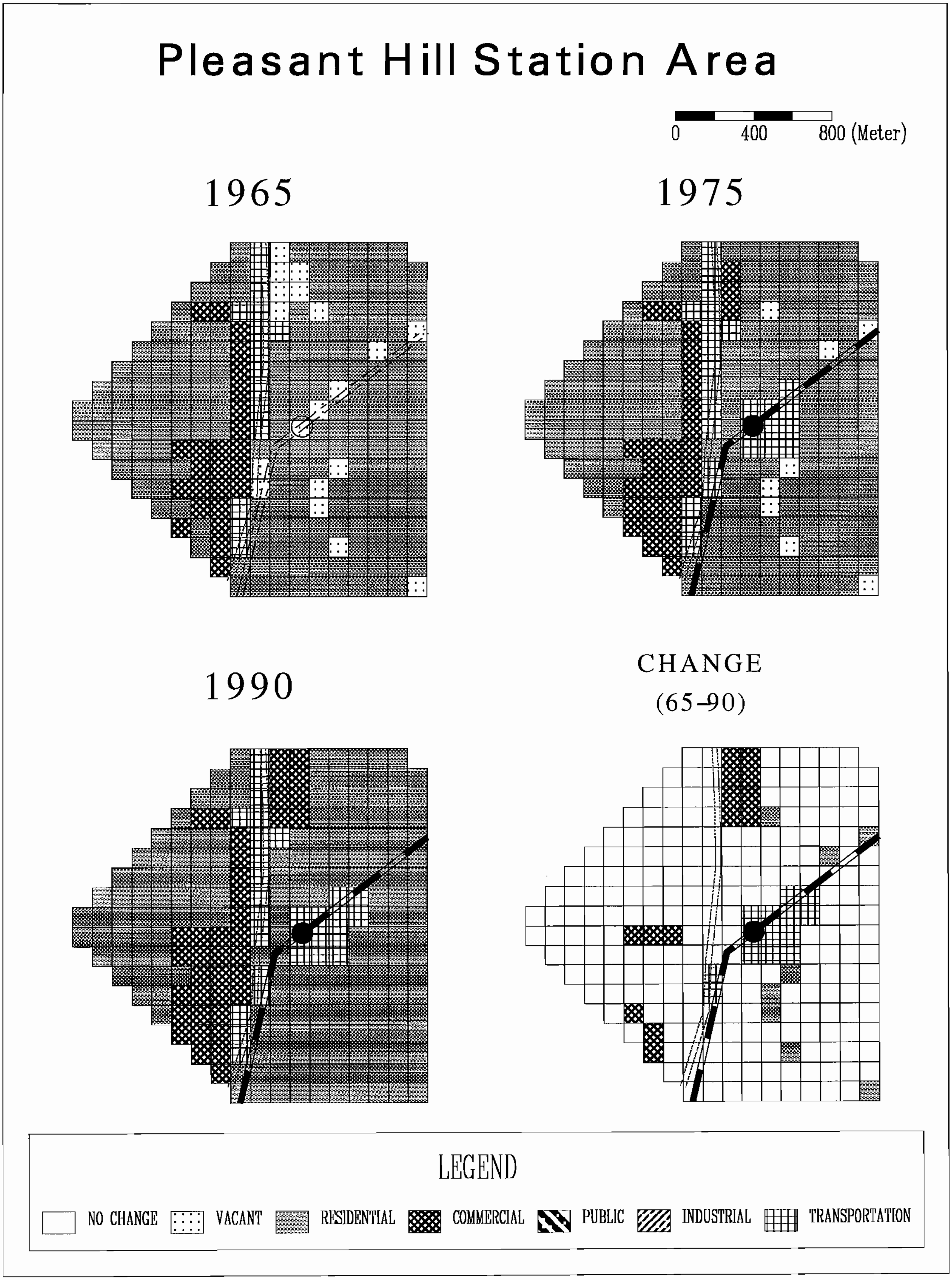
Del Norte Bart Station Area



Fremont Bart Station Area

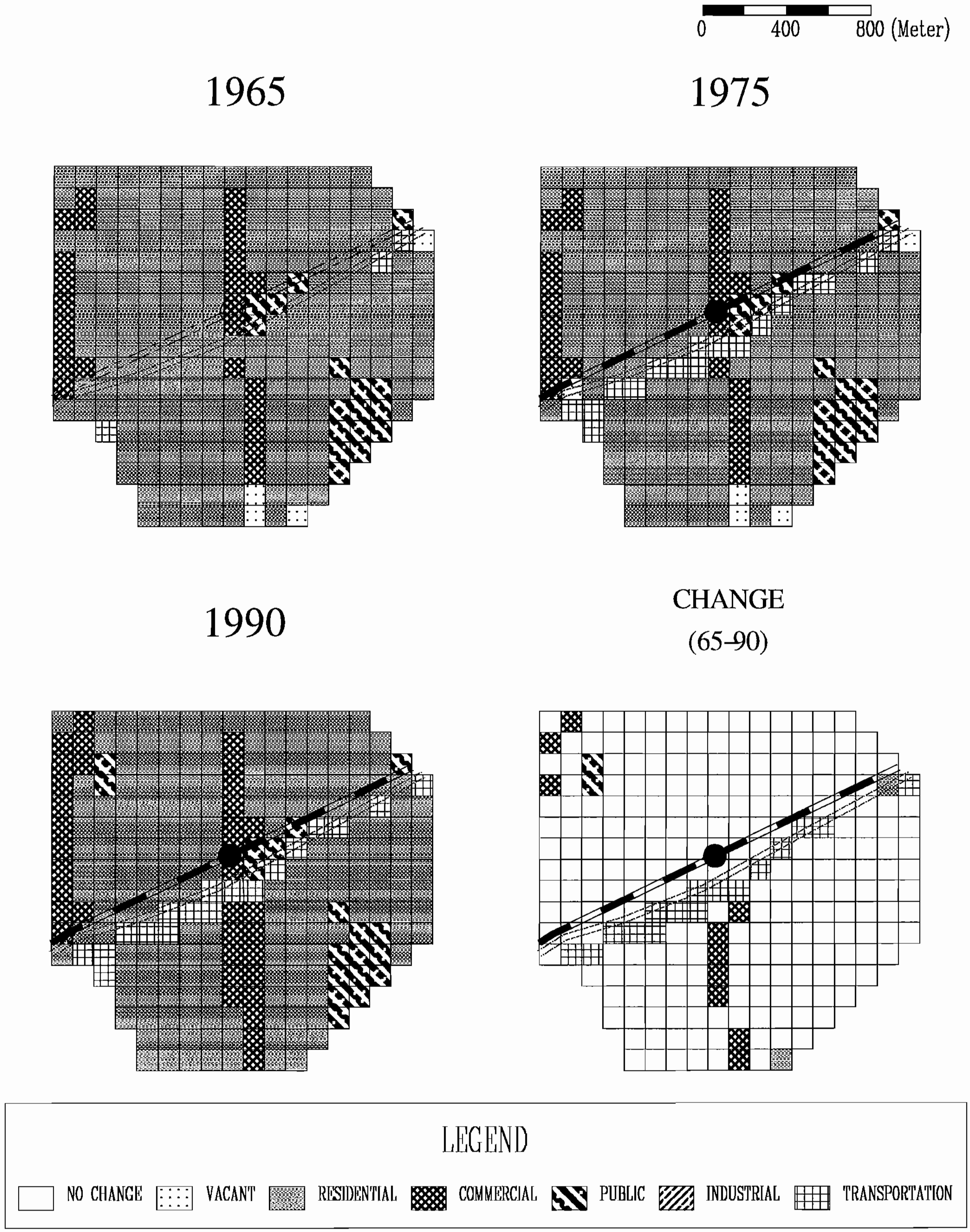


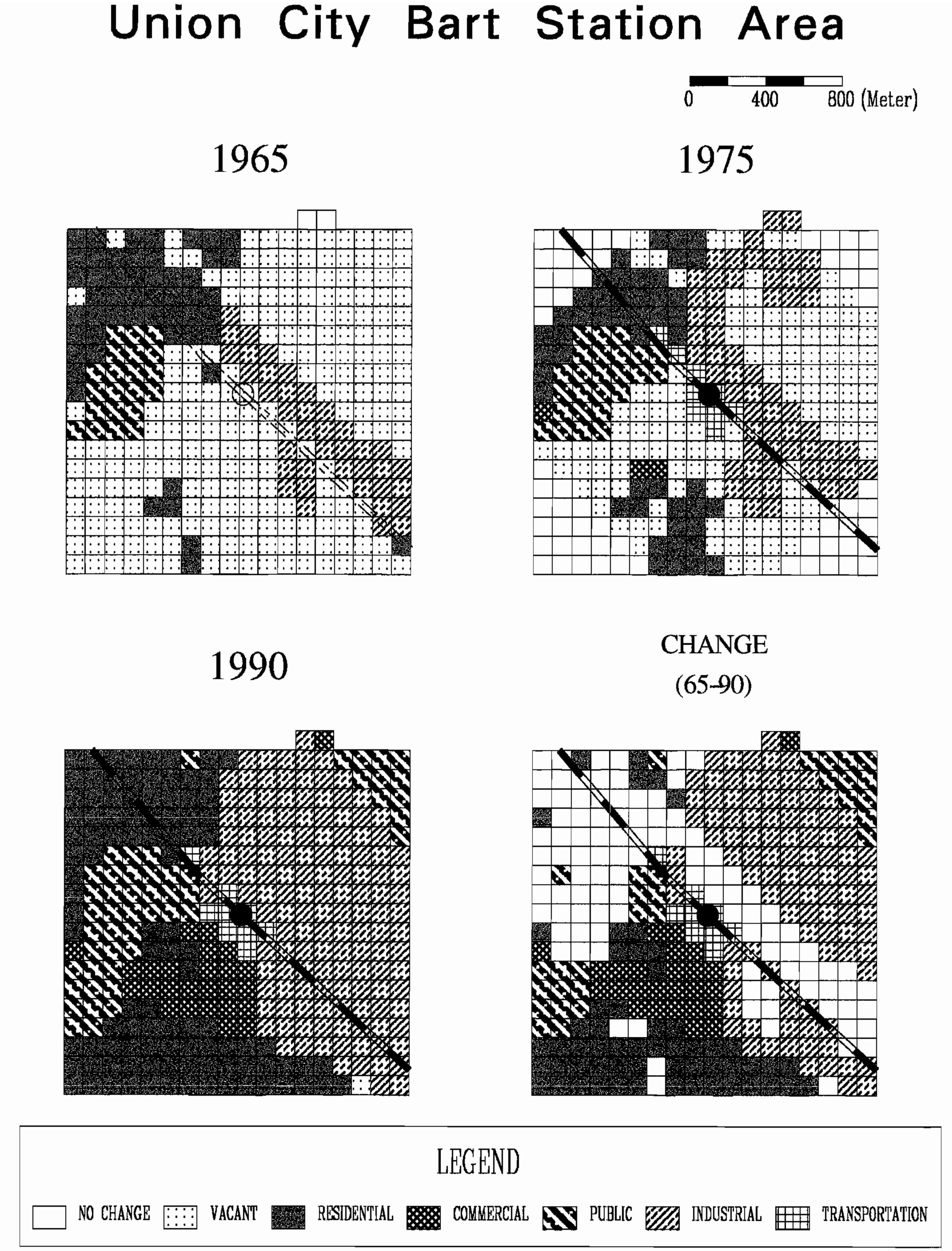

Hayward Bart Station Area
0
400
800 (Meter)
1965
1975
1990
CHANGE
(65-90)
LEGEND
NO CHANGE
VACANT
RESIDENTIAL
COMMERCIAL
PUBLIC
INDUSTRIAL
TRANSPORTATION

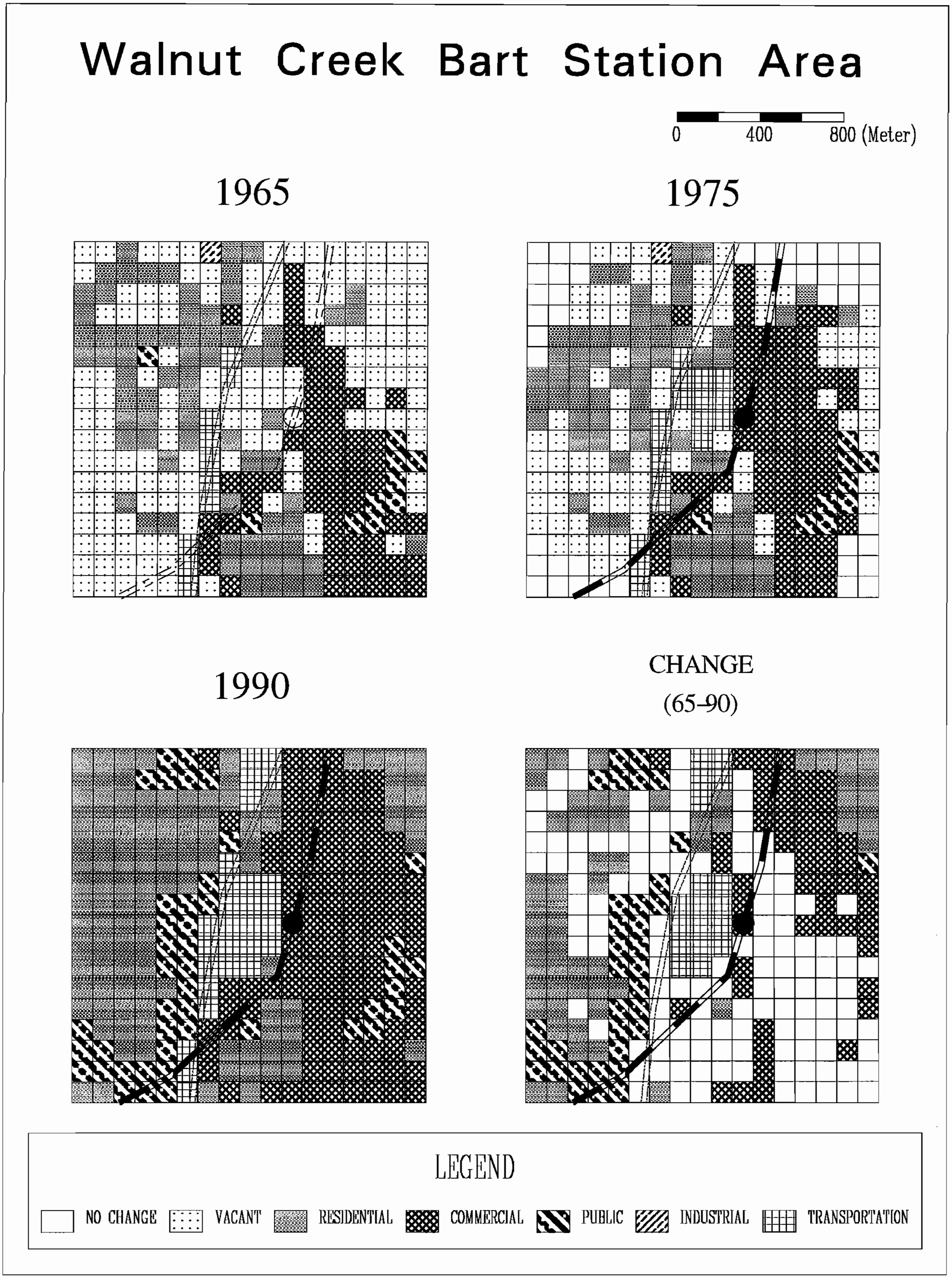


Pleasant Hill Station Area
0
400
800 (Meter)
1965
1975
1990
CHANGE
(65-90)
LEGEND
NO CHANGE
VACANT
RESIDENTIAL
COMMERCIAL
PUBLIC
INDUSTRIAL
TRANSPORTATION

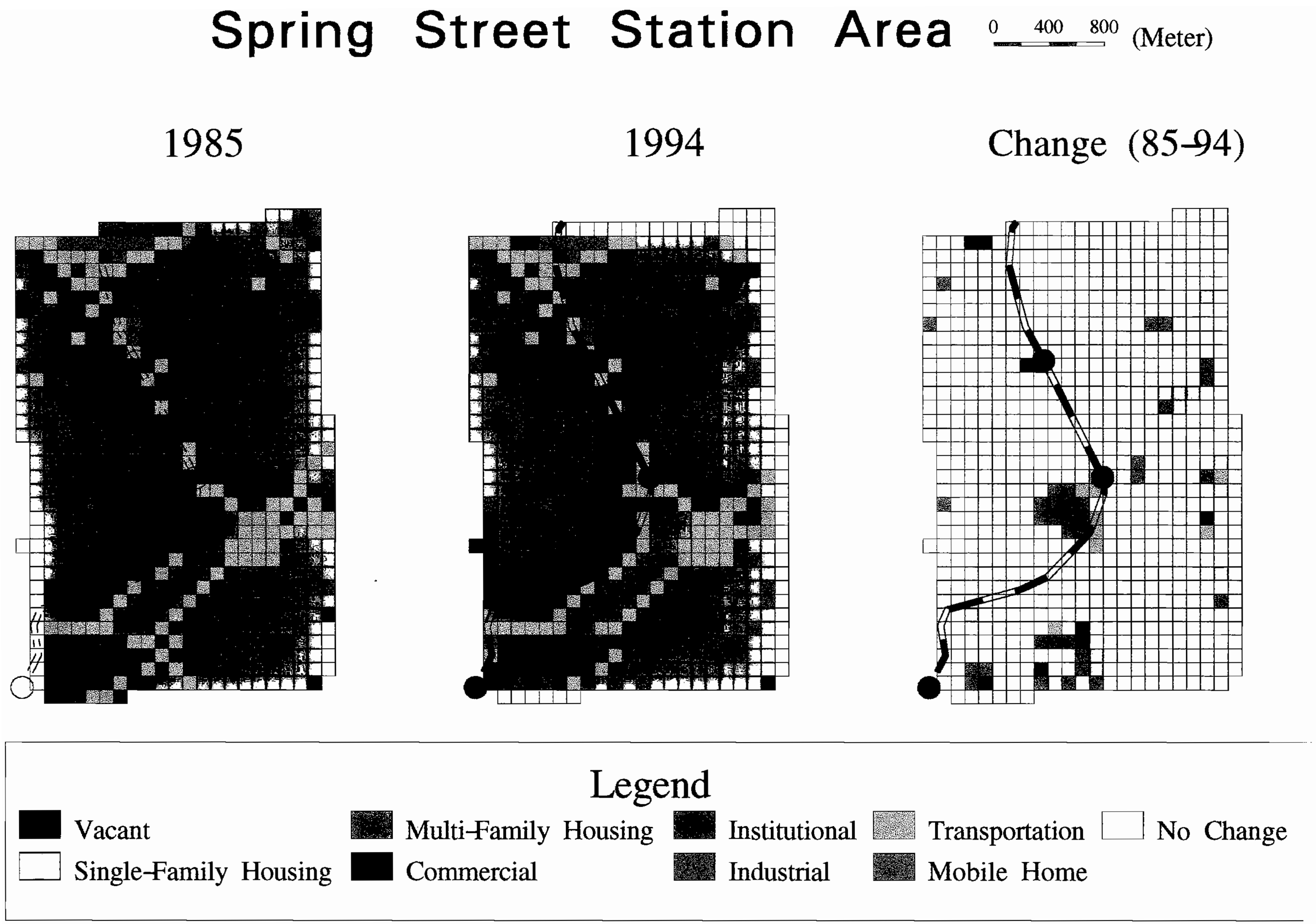
Rockridge Bart Station Area

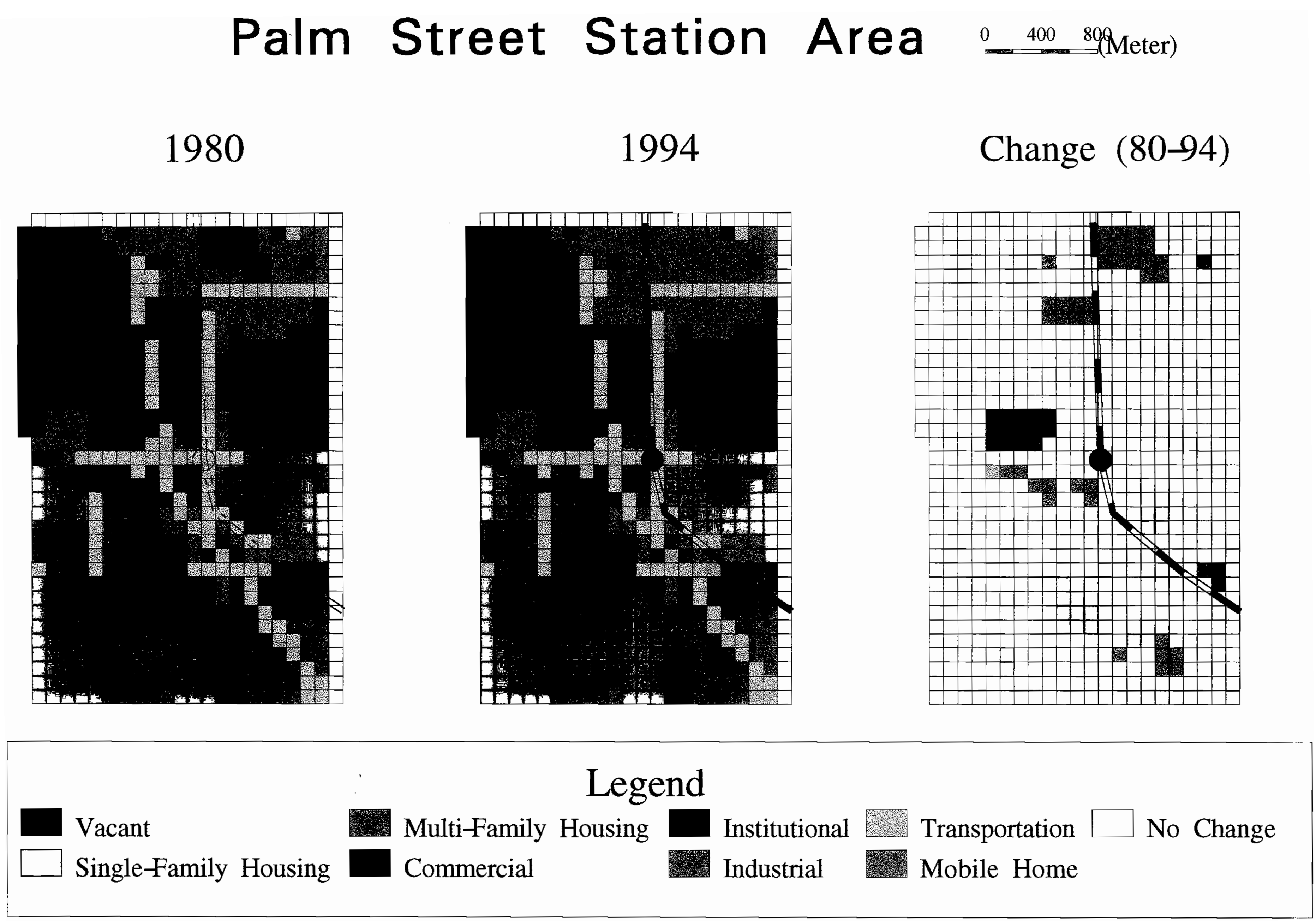



Union City Bart Station Area
0 400 800 (Meter)
1965
1975
1990
CHANGE
(65-90)
LEGEND
NO CHANGE
VACANT
RESIDENTIAL
COMMERCIAL
PUBLIC
INDUSTRIAL
TRANSPORTATION


Walnut Creek Bart Station Area
0
400
800 (Meter)
1965
1975
1990
CHANGE
(65-90)
LEGEND
NO CHANGE
VACANT
RESIDENTIAL
COMMERCIAL
PUBLIC
INDUSTRIAL
TRANSPORTATION

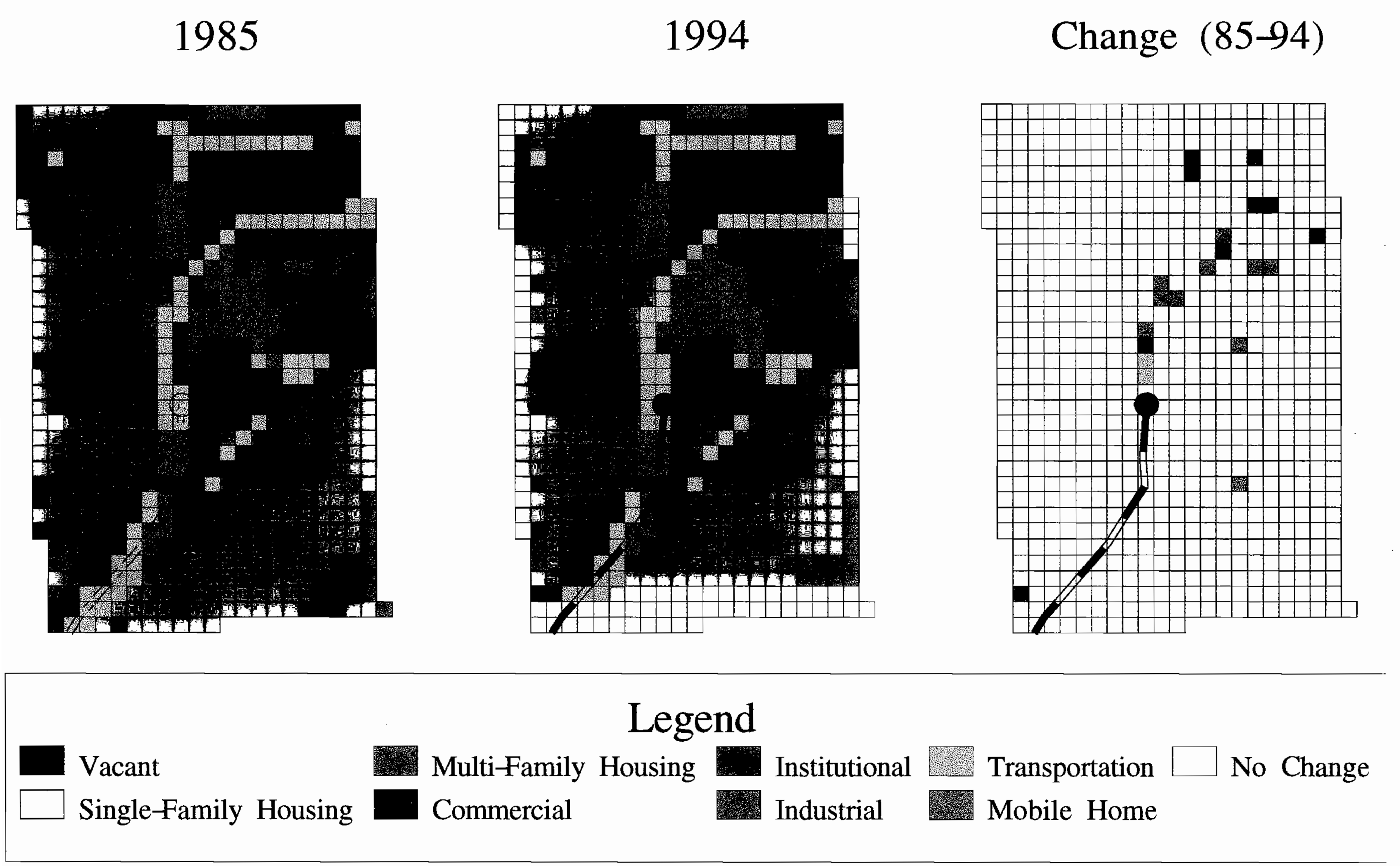
Appendix C: Dominant Land Uses Around Four San Diego Trolley Stations: 1985, 1994

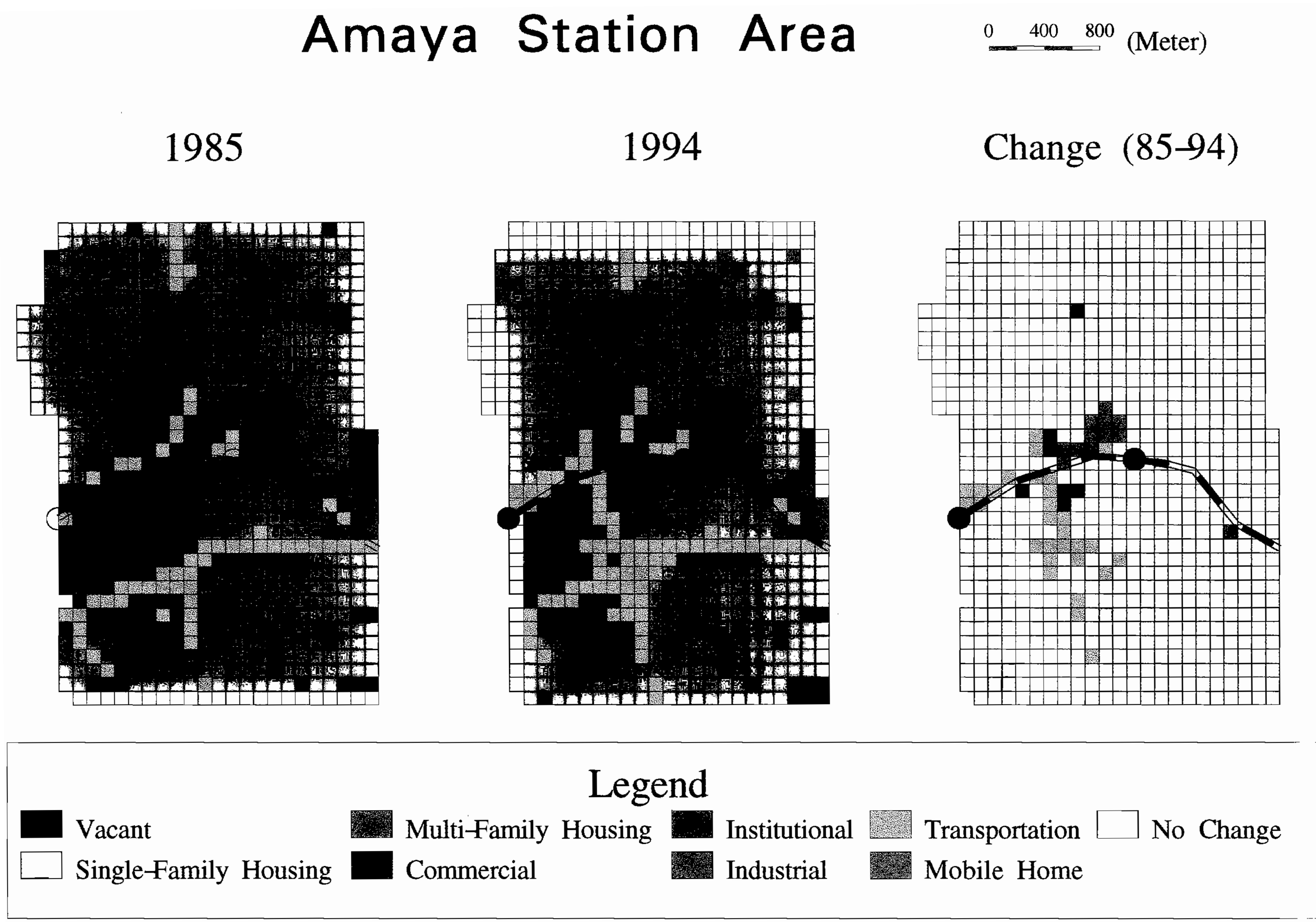

Spring Street Station Area
0 400 800 (Meter)
1985
1994
Change (85-94)
Legend
Vacant
Single-Family Housing
Multi-Family Housing
Commercial
Institutional
Industrial
Transportation
Mobile Home
No Change


Palm Street Station Area
0 400 800 (Meter)
1980
1994
Change (80-94)
Legend
Vacant
Single-Family Housing
Multi-Family Housing
Commercial
Institutional
Industrial
Transportation
Mobile Home
No Change

El Cajon Station Area

0 400 800 (Meter)




Amaya Station Area
0 400 800 (Meter)
1985
1994
Change (85-94)
Legend
Vacant
Single-Family Housing
Multi-Family Housing
Commercial
Institutional
Industrial
Transportation
Mobile Home
No Change

Notes

[1]Or, in areas where land and construction costs are high, to provide a cost-efficient alternative to freeway expansion.

[2]Vesterby and Heimlich defined "fast growth counties" as counties that grew by 25,000 persons and 25 percent between the early 1970s and early 1980s.

[3]Vesterby and Heimlich also noted (at 283-84), however, that the rate of household formation has exceeded population growth rates in recent decades.

[4]The single most significant variable in Lee's first model was found to be the simultaneous change in development of the four cells contiguous to the one under investigation. Contiguous development present at the start of the period was not a significant predictor.

[5]An exception is Cervero and Landis (1992), and Cervero (1993).

[6]Some longitudinal studies have also been quasi-experimental. That is, they have involved comparisons of price changes between sites nearby transportation facilities (the "experimental group") and those more distant (the "control group").

[7]The choice of facility and approach is mostly a function of study age. Older studies — those undertaken in the 1950s and 1960s — tend to focus on the impacts of highways, and generally take a longitudinal approach. More recent studies focus on transit capitalization, and rely on hedonic models.

[8]The selected samples included a complete set of recorded sales during the April-June 1990 period. Excluded from the samples were homes that were excessively inexpensive (less than $50,000), excessively expensive (greater than $500,000), or excessively small (one bedroom or less).

[9]The last year of positive house price appreciation across California was 1990. Since that time, real housing prices have either been flat or trending downward (1991-92), depending on the specific area.

[10]Home sales were assigned to census tracts as follows: First, each home sale was "address-matched" to a street map using a geographic information system. Next, a map of census tracts was overlaid on top of the street map to determine which homes were in which tracts. This procedure was accomplished using ARC/Info.

[11]In areas with minimal turnover, housing sales prices are determined at the margins according to transactions between a limited number of buyers and sellers. In such cases, housing prices track with the incomes of buyers, and not necessarily with the incomes of existing residents.

[12]In contrast to the BART and CalTrain, the light-rail systems covered in this study were entirely within a single city limit. Hence a second analysis controlling for inter-jurisdictional differences in service quality and taxes is not necessary.

[13]County tax assessors generate annual estimates of commercial property values, but such estimates rarely square with market values. In California, property is only reassessed when it is sold, as per the provisions of Proposition 13.

[14]The issue of data coverage is much less severe at the origin end of most transit trips — typically the home-based end. Riders arrive at transit stations via a variety of modes (including private cars and buses), and often from much further distances. This serves to extend any capitalization gradient, and makes it easier to identify with a limited number of data points.

[15]Most computer-based street maps include the left-hand-side and right-hand-side address ranges associated with each block or street intersection. For example, the address ranges coded for Elm Avenue at its intersection with 1st Street would be 100 (right-hand side) and 101 (left-hand side); the address ranges for Elm Avenue at its intersection with 2nd Street would be 200 and 201, respectively. A computerized address-matching program places each building at a location by matching the precise building address to an interpolated point between intersections corresponding to the building address. A building with an address of 150 Elm Street, for example, would be located on the right-hand-side of Elm Street, halfway between 1st and 2nd Avenues.

[16]Both of these operations were undertaken using MapInfo for Windows.

[17]1965 aerial photographs were undertaken in preparation of BART station construction.

[18]Formally, suppose there exist j types of possible land uses, indexed by $j = 1....J$. A given area of land will be converted to use i if the profit (or land rent) associated with the conversion, Ri, satisfies:

$$Ri > Rj \text{ for all } j = i$$

That is, the area will be converted to the most profitable use. The profit derived from each use type, Rj, is determined by a set of attributes, $X1,.....Xn$; some which are observed, some of which are not. Because of the unobserved attributes, the determination of the land conversion is modeled as a probabalistic process. Let $P[i\{1,...j\}]$ be the probability that a site will have use i given j alternative types of land use. Under the profit maximization assumption noted above, this can be written as:

$$P[i\{1,...j\}] = Prob[Ri > Rj \text{ for all } j = 1, j \{1,..j\}]$$

Econometrically, we consider this probability to be a function of the observed attributes $X1,..Xm$. The logit model is a simple estimator of this function that satisfies the above assumptions. See McFadden (1978) for a similar derivation of the logit model as applied to the case of residential location.

[19]As noted in Chapter Three, proximity to a BART station adds value to homes five miles as well as 50 feet from BART stations. Given BART's broad sphere-of-influence with respect to home prices, might we not also expect the system to have a similarly broad reach with respect to land use changes?

[20]In Chapter Five, land uses were delineated according to hectare (100m x 100m) grid-cells. In Chapter Six, we join adjacent hectare grid-cells of similar use into land-use polygons. The resulting polygons vary widely in shape and area, unlike the grid-cells upon which they are based.

[21]Unlike the housing price analysis included in Chapter Three, in which we measured the road network distance from each home to the closest BART station.

[22]At some level, this is a simultaneous, and not a sequential relationship. That is, land-use polygons that change from undeveloped to residential use directly contribute to city population growth. Similarly, population growth in a city adds puts conversion pressures on land within city boundaries. To avoid the problem of simultaneity, the POPCHNG% and EMPCHNG% variables are based on growth during the previous five years (1980-85).

[23]Heikila, et al.

[24]The distinction between higher-order uses and lower-order uses, although common, is somewhat artificial. The idea of order is based on relative land rent or profitability. Higher-order uses are presumed to be more profitable per unit of land, and thus pay higher land rents than lower-order uses. In fact, order may depend as much on prevailing conditions in local real estate markets as on land use. If, for example, residential space is in short supply while commercial space is plentiful, then returns to residential space may well exceed those to commercial space.

[25]With such small acreage totals involved, there is a strong possibility that at least some of the observed changes are really due to differences in hectare classification between the 1985 and 1990 inventories, and not to actual land use changes. In Contra Costa County, for example, 163 acres were reported to have been redeveloped "downward" from a developed to an undeveloped use.

[26]Capitalizing this fee at an interest rate of five percent yields a total value of $1,000. This is far less than the housing price premium associated with BART access.

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