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The University of California Transportation Center

University of California
Berkeley, CA 94720

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Travel Choices in Pedestrian Versus Automobile Oriented Neighborhoods

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Abstract

The New Urbanism movement calls for redesigning American neighborhoods so that they are less oriented toward automobile travel and more conducive to walking, bicycling, and transit riding, especially for non-work trips. New Urbanism calls for a return to compact neighborhoods with grid-like street patterns, mixed land uses, and pedestrian amenities. This paper investigates the effects of New Urbanism design principles on both non-work and commuting travel by comparing modal splits between two distinctly different neighborhoods in the San Francisco Bay Area. The neo-traditional neighborhood, Rockridge, and the nearby conventional suburban community, Lafayette, were chosen as case studies because they have similar income profiles, freeway and transit service levels, and geographical locations. Rockridge residents averaged around a 10 percent higher share of non-work trips by non-automobile modes than did residents of Lafayette, controlling for relevant factors like income and transit service levels The greatest differences were for shop trips under one mile. Modal splits were more similar for work trips, confirming the proposition that neighborhood design practices exert their greatest influence on local shopping trips and other non-work purposes For work trips, compact, mixed-use, and pedestrian-oriented development appears to have the strongest effect on access trips to rail stations, in particular inducing higher shares of access trips by foot and bicycle.

1. INTRODUCTION

In recent years a movement called "New Urbanism" has surfaced that calls for fundamental changes in how American communities are designed and built (Katz, 1994) New urbanists embrace many of the design principles of late-19th and early-20th American towns. Among these are compact development, a mixture of land uses and housing types, a grid-like street pattern well-suited to walking, and prominent civic spaces. Traditional towns, like Annapolis, Maryland and Savannah, Georgia, are held as exemplars of old-fashion, pedestrian-oriented communities where thousands of residents live within an easy and pleasant walk of the town center.

A central premise of the New Urbanism movement is that designing American communities like those of yesteryear will reduce autom[illegible] age and dependency by making public transit, walking, and bi[illegible] cent federal and state clean air requirements have [illegible] ng land-use initiatives as one of a dozen or so possib[illegible] Several cities, notably San Diego, California an[illegible] nmunity design guidelines based on New Urban[illegible] ucle miles traveled (VMT) and enhancing the qua[illegible] ne New Urbanism ideas have captured the imaginati[illegible]. there has been little research to support the [illegible] t-supportive community designs will actually red[illegible]

The few commun[illegible] neo-traditional in their designs offer little insight into the[illegible]ons. Seaside, widely considered the nation's first neo-traditional community, is a fairly exclusive beach resort on Florida's panhandle and outside a metropolitan area; analysis of travel patterns among Seaside's residents would have limited applicability elsewhere. Two other examples -- the Kentlands, a Maryland suburb of Washington, D.C., and Laguna West, outside of Sacramento, California -- do not yet have enough retail or employment activities to qualify them as bonafide mixed-use communities. Both also receive modest levels of public transit services.

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In light of there being few good examples of neo-traditional or "New Urban" communities, this study examines travel behavior in existing neighborhoods which embody the characteristics of either pedestrian or auto-oriented designs The research focuses on how contrasting residential built environments influence mode choices, both for work and non-work trips. It probes whether factors like higher densities, mixed land uses, pedestrian-oriented street designs, and neighborhood retail clusters, in combination, encourage people to give up their cars and walk, take transit, or travel by some other means. The degree to which this is demonstrated should either lend credence or cast skepticism over the transportation benefits of New Urbanism design principles

2. PAST RESEARCH ON THE TRAVEL IMPACTS OF NEIGHBORHOOD ENVIRONMENT

A considerable body of literature now exists on the impacts of built environments on travel choices. Much of this research, however, has focused on commute trips to large employment sites (Cervero, 1989; Cambridge Systematics, 1994); until recently, less attention has been given to the effects of neighborhood designs on travel demand, particularly for non-work purposes. This section briefly summarizes some of the relevant literature on the travel impacts of neighborhood built environments.

One of the earliest studies on the travel demand effects of neighborhoods was by Levinson and Wynn (1963), who found that neighborhood density substantially reduces vehicle trip frequency. Their results indicated that if neighborhood density and distance-to-CBD were both to increase by one standard deviation, average household VMT would drop by roughly one third. Subsequent work by Pushkarev and Zupan (1977) confirmed that both population density and proximity to CBD are critical factors in justifying investments in heavy rail transit systems. To support light rail services on five-minute peak headways, for instance, Pushkarev and Zupan concluded that densities of at least nine dwelling units per acre within a fifteen mile radius of a downtown would be required.

Handy's (1993) comparison of shop trip-making between "traditional" neighborhoods and more auto-oriented ones in the San Francisco Bay Area is one of the most in-depth analyses on non-work travel to date. She found those living in traditional neighborhoods made two to four more walk/bicycle trips per week to neighborhood stores than those living in nearby areas that were served mainly by automobile-oriented, strip retail establishments. Residents of mixed-use neighborhooods, however, averaged similar rates of auto travel to regional shopping malls, suggesting that internal walk trips did not replace, but rather were in addition to, external driving trips. Fehrs and Peers Associates (1992) found substantially higher rates of foot and transit travel in traditional communities versus conventional suburban subdivisions of the San Francisco Bay Area; their study, however, did not control for the influences of differing transit service levels or socio-economic characteristics, like incomes, among neighborhoods. A more recent study by Ewing et al. (1994) compared work and non-work travel in six communities of Palm Beach County, Florida. The authors found that "sprawling suburban" communities generated almost two-thirds more vehicle hours of travel per capita than the "traditional city", concluding that "density, mixed uses, and a central location all appear to depress vehicular travel" (p. 19) Another study, conducted for the Seattle region by Frank (1994), found that mixed-use neighborhoods were most strongly associated with high rates of walk trips to work, but rather surprisingly had no influence on shopping trips.

Two studies which are particularly germane to our analysis because they focused on the San Francisco Bay Area and introduced statistical controls are those by Holtzclaw (1990) and Kitamura, Mokhtarian, and Laidet (1994). Using data from smog-check odometer readings, Holtzclaw found that residents of San Francisco neighborhooods drove, on average, only one-third as many miles each year as residents of Danville, an East Bay suburb with comparable incomes In a more recent study of 28 California communities, Holtzclaw found that the number of automobiles and VMT per household fell by one-quarter as densities doubled, and by around 8 percent with a doubling of transit services, again controlling for factors like household income.

Kitamura et al. studied the influence of different factors on modal splits for some 16,300 person trips (all purposes combined) recorded among residents of five Bay Area neighborhoods. The factors studied were. area descriptors (mixed use, density), pedestrian/bicycle facilities; housing choices (homeownership, backyards), accessibility indicators (proximity to land uses and transit); and neighborhood quality (e g., perception of walking quality and levels of local transit service). All of these factors, including density and mixed uses, were measured as simple 0-1 dummy variables.

While the study concluded that "neighborhood characteristics add significant explanatory power when socio-economic differences are controlled for", on closer inspection this appears to be a somewhat generous assessment. This is partly because some of the models measured total person trips as a function of these factors; "total person trips" is not a particularly useful measure since the number is a direct function of neighborhood size and sample rate (which varied from 2,768 for the North San Francisco neighborhood to 3,696 for a San Jose neighborhood) For the modal split analyses, the dummy variable indicators of density, mixed uses, and pedestrian/bicycle facilities added only a fraction of a percent to the explanatory powers of models, and generally produced t-statistics below the 0.10 probability level. The most significant explainers were the geographic locations of the surveyed neighborhoods, which themselves were correlated with factors like residential density. Besides geographic location, the only significant predictors of transit modal shares were BART access and the availability of parking, and the only significant correlate of non-motorized modal shares was the presence of high density. None of the indicators of the presence of pedestrian and bicycle facilities were significant.

The recent Land Use-Transportation-Air Quality (LUTRAQ) study conducted by Parsons, Brinckerhoff, Quade and Douglas (1993) for the Portland, Oregon region has perhaps been the most ambitious effort to gauge the travel impacts of "pedestrian-friendliness". In the LUTRAQ study, neighborhoods were subjectively rated on a 1-5 scale by a panel of experts in terms of: (1) ease of street crossings; (2) sidewalk continuity, (3) local street characteristics (grid-iron versus cul-de-sac patterns), and (4) topography. While simple correlations showed that neighborhoods with highly-rated pedestrian environments averaged more transit trips, the "pedestrian-friendliness" variable provided only marginal explanatory power in a regression model of neighborhood VMT.

3. RESEARCH DESIGN

3.1 The Dilemma of Studying Travel Impacts of Neighborhood Environments

This analysis was an outgrowth of an earlier, unsuccessful one that attempted to measure the effects of the land-use environment and urban design on non-work trip making. That effort sought to model how some forty indicators of neighborhoods' built environments (e.g., average block lengths, residential densities, levels of mixed land uses, proportions of intersections that are four-way, continuity of sidewalk system, density of street trees, etc.) influenced non-work modal splits and person miles traveled. Once density entered the model equations, however, the remaining built environment variables added little significant marginal explanatory power. This is because most were highly correlated with residential densities -- that is, relatively dense neighborhoods tended to have more mixed uses, average shorter block lengths, have grid-like street patterns, feature continuous sidewalk networks, etc. In that only twelve neighborhoods were studied, moreover, there were only twelve possible data values for land-use variables. Each data record consisted of travel diary and person socio-economic information, plus the appended data on the land-use environment. Thus, there tended to be far less variation in the built environment variables than most of the control variables, like vehicle ownership levels and household incomes.

In general, the absence of rich land-use and urban design data at the tract level is a significant barrier to carrying out neighborhood-scale studies of how the built environment shapes travel demand. Limited travel diary data for specific census tracts or small-scale analysis zones is also an inhibiting factor. Until travel diary data are compiled for at least thirty households per tract across at least fifty tracts, and detailed land-use and design data are likewise compiled for the same fifty or more tracts, then there will unlikely be a sufficiently rich data base for accurately measuring the impacts of neighborhood built environments on travel demand. At present, there are no secondary data sources in any metropolitan area that meet such data requirements.

Even if considerable resources were spent in compiling detailed land-use, urban design, and travel diary information across a large number of census tracts, it is not altogether clear whether many land-use and urban design variables would show up as statistically significant. As noted, this is partly because of the high correlation between neighborhood densities and most other indicators of neighborhood built environments, like levels of mixed uses and block length. Moreover, cruder and less statistically powerful indices are often used to measure built environments, often relying on subjective ordinal measures (as in the LUTRAQ study for the Portland, Oregon region) or simply dummy variables (as in the Kitamura et al., 1994 study of the Bay Area); consequently, richer, ratio-scale control variables, such as household incomes and transportation prices, tend to have a predictive advantage. And, of course, it could very well be that once density is controlled, urban design factors indeed contribute very little to travel demand. In a study of transit-supportive designs across a number of U.S., Cervero (1993, p.220) concluded that "micro-design elements are too 'micro' to exert any fundamental influences on travel behavior; more macro-factors, like density and the comparative cost of transit versus automobile factor, are the principal determinants of commuting choices".

3.2 Research Approach

In light of the problems discussed above, this study compares travel characteristics in two distinctly different neighborhoods in the East Bay of the San Francisco-Oakland region -- Rockridge, an older, compact and mixed-use neighborhood in Oakland-Berkeley with many traditional design qualities, and Lafayette, a post-WWII community dominated by suburban tract housing, spacious community designs, and auto-oriented retail strips and plazas. Given the high multi-colinearity previously found between neighborhood density and urban design in the Bay Area, this approach allowed a simple dummy variable to be employed in representing two fundamentally different built environments The dummy variable assigns a one value for trips made by those living in Rockridge and a zero value for journeys made by Lafayette residents. We would expect a higher probability of non-automobile travel among Rockridge residents, all else being equal, thus a positive sign on the neighborhood dummy variable. Overall, this approach provides an order-of-magnitude estimate on how a compact, mixed-use, pedestrian-oriented neighborhood shapes travel relative to a lower-density, more auto-oriented one that is otherwise very similar.

These two communities are "otherwise very similar" because they lie in the same geographic area of the East Bay, thus they are the same approximate distance to the region's CBD, downtown San Francisco They both have a BART station (on the Concord line), are served by the same regional freeway (State Highway 24), and have comparable median household incomes Thus, the selection of these two communities in modeling the impacts of the built environment on travel demand effectively controls for four key variables: geographic location within the region; household income; levels of regional rail (BART) transit services; and levels of regional freeway access.

3.3 Research Data

In the San Francisco Bay Area, the most extensive regional travel survey is the Bay Area Travel Survey (BATS), last conducted by the Metropolitan Transportation Commission in 1990/91 Unfortunately, there are too few BATS records for any specific census tract or neighborhood to support any rigorous modeling of how the land-use environments of those neighborhoods shape travel choices. BATS, as with most metropolitan surveys, was collected to support regional travel demand forecasting, and thus is meant for macro-level analysis. One could combine tracts to obtain enough trip records to support modeling, however the resulting areas would be quite large, larger than what is traditionally viewed as a neighborhood. For these reasons, primary travel data were instead collected using mailback surveys sent to residents of the targeted neighborhoods.

Travel Surveys

Two separate surveys -- one for work trips and one for non-work trips -- were sent to randomly selected households in six census tracts corresponding to the Rockridge community and six that encompass the town of Lafayette Mailing labels for tracts were obtained from a direct-mail marketing company. The "occupant lists" were based on information compiled from the U.S. Postal Service and include all households, not just homeowners.

Four thousand questionnaires (with prepaid, return address postage) soliciting data on non-work travel were sent to households in the six tracts in the spring of 1994, during a period of good weather; 620 were returned for a response rate of 15.5 percent. Another set of questionnaires compiling commute trip data was sent to four thousand different households in the same tracts during the same period; 840 of these were returned, yielding a response rate of 21 percent.

A streamlined questionnaire which requested minimal travel data was designed in hopes of increasing response rates. This meant, first of all, only compiling data for a single person in the household who responded to the survey; this was nearly always an employed adult. Second, non-work travel data were collected for up to three "main" trips that the respondent made the previous day (which, because of the date most households received the survey, was almost always a weekday); it was up to the respondent to decide what was a "main" trip for non-work purposes. Thus, a complete travel diary was not compiled, though in the vast majority of cases, respondents made no more than three non-work trips on the given survey day. Because of the streamlined survey design, most respondents could complete the non-work trip questionnaire in five minutes or less The survey of work trips, which asked only about the commute made by the respondent during the previous day, was even easier to fill out. Besides trip purpose, data on travel means, trip origin and destination. departure and arrival time, trip length, and the amount paid for parking were collected in both surveys. In addition to travel data, questionnaires elicited information about respondents, such as their annual salaries and age, as well as about their households, such as the number of vehicles available and household size

Comparisons of survey data with census statistics for the twelve tracts within the two neighborhoods confirmed that, despite the somewhat low response rate, surveyed households were fairly representative of the population at-large. For example, the 1990 census indicated that 63.6 percent of housing units in the Rockridge tracts were single-family dwellings; this compares to 61.7 percent in our survey Lafayette's 1990 median household size was 2.5; in our survey, it was 2.65. Compared to the census, surveyed respondents were slightly older and tended to live in slightly larger households.

Data Base

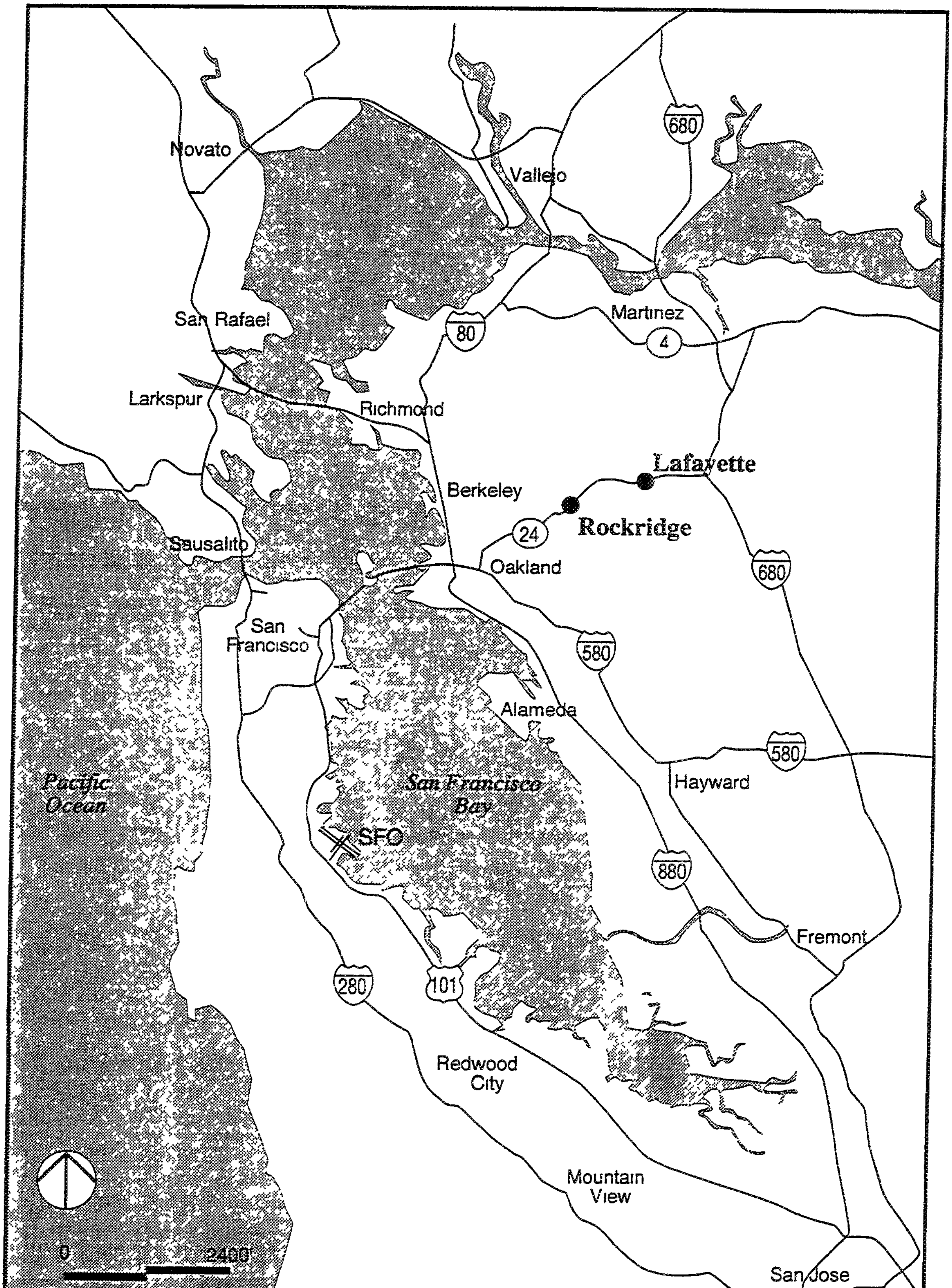
In building a data base for this research, every person trip was treated as a data record. The socio-demographic and household data compiled for the person making the trip was appended to each record. So was a code specifying whether the person resided in Rockridge or Lafayette.

4. STUDY AREAS

Map 1 shows the regional location of the two case-study communities. The dividing line between them is the East Bay hills. Rockridge lies west of the hills, in the older, more urbanized part of the East Bay. Rockridge grew around the early Key System streetcar line that once served the East Bay, and today retains many features of a streetcar suburb. Rockridge is very compact, with mostly apartments and detached units with small yards and narrow sidelots. It features a finely grained and integrated mixture of land uses, in particular the very pedestrian-friendly College Avenue commercial district. Lafayette lies west of the East Bay hills. It is Rockridge's polar opposite -- with almost exclusively large-lot tract housing, curvilinear streets, and an auto-oriented retail strip. These two neighborhoods, then, offer the unique advantage that they are in a similar subregion, have similar incomes, and receive similar transportation services; yet, mainly because of a natural dividing line, the East Bay hills, they are worlds apart in terms of their physical and land-use makeups. In principle, they should provide a rich context for ferreting the relationships between built environments and travel choices.

4.1 Similarities and Differences

Table 1 summarizes the common and differing characteristics of the two case-study neighborhoods In 1990, both averaged fairly high median household incomes, well above the regional average of $41,600 Housing prices and rents are also relatively high in both areas Both have a similar age structure and are predominantly white, although Rockridge has a much higher share of African-Americans (16.3 percent) relative to Lafayette (under one percent). Rockridge also has a higher share of single households (33.7 percent versus 18.6 percent) and accordingly a smaller average household size. This is partly due to Rockridge's population of students who attend the nearby University of California at Berkeley, which also results in a high share of college-educated adults. And, as noted, both communities are on the Concord BART line and have a rail station near their commercial districts. Surface bus services are also similar -- AC Transit operates three bus routes in each community, though Rockridge enjoys more frequent services (average peak headways of 2.8 minutes versus 9 7 minutes in Lafayette).



Map 1. Location of Rockridge and Lafayette in the San Francisco Bay Area

Table 1: Comparison of Rockridge and Lafayette Communities, 1990

	Rockridge	Lafayette	Percent Difference[1]
Common Characteristics			
Household and Housing Attributes			
Median household income	$58,770	$61,071	3.9
Persons per household	2.2	2.5	13.6
Median housing value	$322,595	$392,853	21 7
Median monthly rent	$682	$843	23.6
Resident Attributes			
Median age	37.3	39.8	6.7
Percent persons who are white	73.8	88.2	14.4
Percent adults college educated	44.5	40.7	3.8
Transportation Attributes			
BART headways (minutes, a.m peak)	3	3	0.0
No of buslines serving area	3	3	0.0
Differing Characteristics			
Residential Attributes			
Housing density (units per square mile)	2,194	655	234.9
Percent housing that is single-family detached	63.6	78 4	14.8
BART Station Vicinity[2]			
Blocks per square mile	103	47	119.2
Intersections per square mile	127	64	98.4
T-intersections	37	85	129.7
Four-way intersections	29	8	262.5
Cul-de-sacs	5	31	520.0
Retail District Attributes			
Average block length (ft., major roads)	80	380	375.0
Percent of blocks with curb cuts	100	10	90.0

[1] Percentage data are expressed as percentage point difference.
[2] One square mile area around station

Sources 1990 Census of Population and Housing, U.S Bureau of the Census, and field surveys

In terms of their land-use environments, Table 1 reveals how different the two neighborhoods are. Rockridge is far denser and has many more apartments and attached housing units. It also has a more fine-grained urban pattern -- with around twice as many blocks and intersections within a square mile of its BART station as does Lafayette. The more grid-like, pedestrian-oriented street pattern of Rockridge is also reflected by the much higher share of four-way intersections, matched by relatively few T-intersections and cul-de-sacs. Figure 1 highlights the differences in street and block patterns for the one square mile centered on the BART stations of the respective neighborhoods.

4.2 Physical Development Patterns of the Two Neighborhoods

The contrasting histories and physical patterns of development in Rockridge and Lafayette are briefly summarized below. Differences in the land-use compositions and physical make-up of their respective commercial districts are highlighted.

Rockridge

The Rockridge neighborhood of Oakland is a prototypical "transit-oriented" community. Essentially a streetcar suburb of San Francisco, Rockridge blossomed around the turn of the century as a major stop on the East Bay's extensive network of interurban and trolley lines. This system provided the first push of suburbanization in the San Francisco region, linking the more affluent hillside communities of the East Bay by rail and ferry to downtown (Vance, 1964). As shown in Figure 1, the influence of the early streetcar system is clearly expressed in Rockridge's grid-like built form.

At the heart of the neighborhood is a retail district aligned along College Avenue, a street which once accommodated a crosstown streetcar line. Figure 2 shows the grain of development along the College Avenue district south of the BART station and along residential side streets. Retail shops form an unbroken streetwall that define the avenue. Few blocks are interrupted by curbcuts since the neighborhood developed when streetcars were the predominant mode of transportation. Storefronts are scaled to the pedestrian -- shops are typically 40 feet or less in

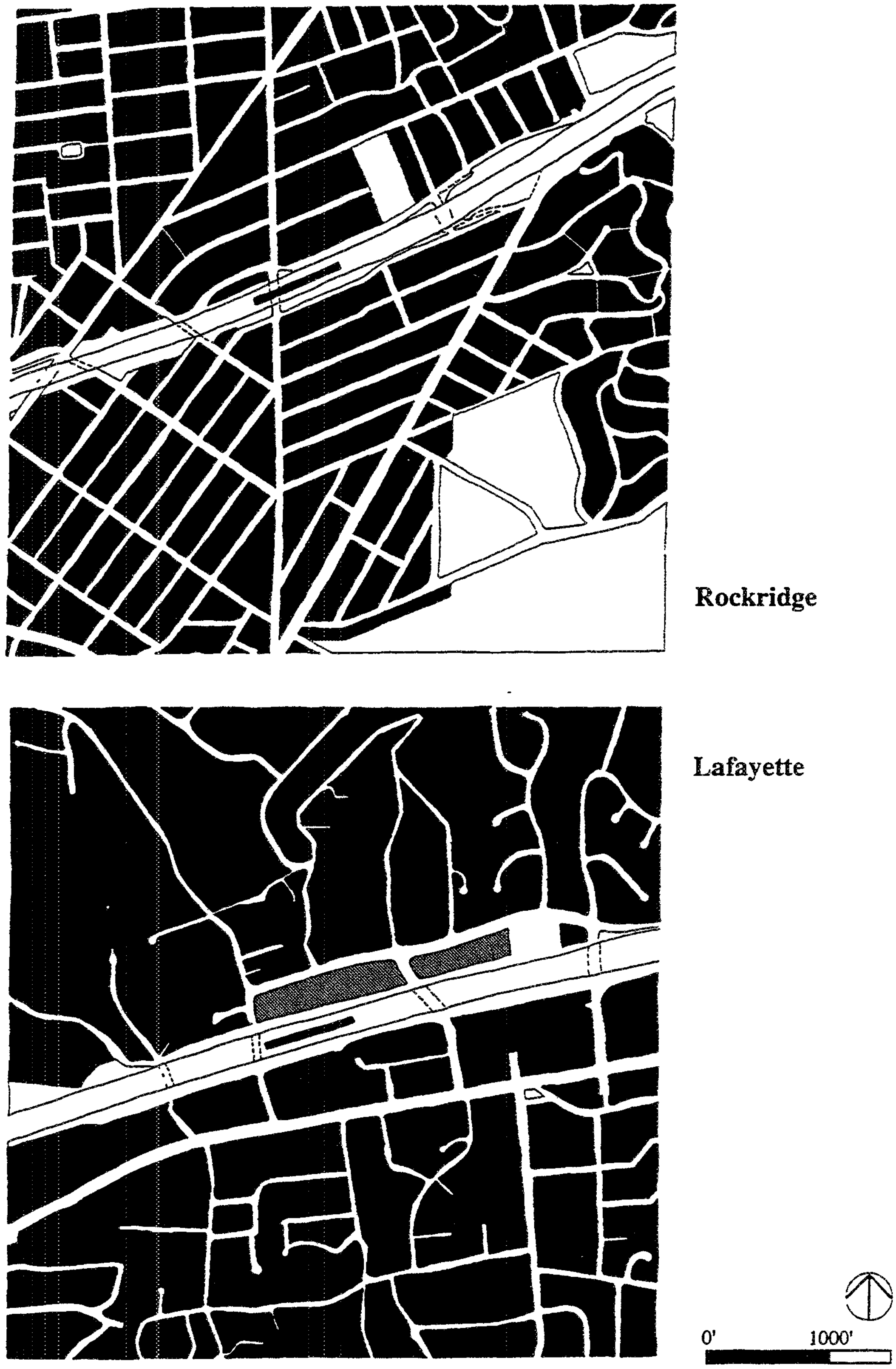


Figure 1. Comparison of Street and Block Patterns, Rockridge and Lafayette

width, producing four or more shops on a typical block. Building entries open directly onto the sidewalk providing a nearly continuous sequence of showcase windows and shop entries. Many stores have loft apartments or offices above. Parking is accommodated on the street or behind buildings; few parking lots directly face College Avenue.

Like many streetcar suburbs which depended on trolleys for real estate speculation, Rockridge's residential areas feature regularity in lotting patterns and architecture. California bungalows, with porches facing the street and garages tucked behind, dominate residential streets. Small two, three and four-unit residential buildings make up 22 percent of Rockridge's housing stock, and an estimated one-third of detached units have real-lot accessory units. This mix of housing has created high average densities on many lots that do not disrupt the prevailing scale and grain of the neighborhood.

The entire Rockridge neighborhood is linked by an integrated network of sidewalks and pedestrian paths. Shade trees occupy the planting strip between most sidewalks and streets. In some locations, mid-block pedestrian paths allow convenient access to transit lines. Overall, Rockridge is a very pedestrian-friendly neighborhood.

Lafayette

The community of Lafayette largely post-dates World War II. Prior to this, Lafayette was primarily an agricultural and summer home community. It was the completion of the twin bore Caldecott Tunnel through the East Bay hills in 1937 that greatly improved access to Lafayette and paved the way for new growth beginning in the 1950s.

The scale and configuration of development in Lafayette reflects a stronger automobile orientation. As shown in Figure 1, Lafayette's street network is less regular and more curvilinear than Rockridge's. Streets are also wider. Mount Diablo Boulevard, the community's major thoroughfare, is 75 feet from curb-to-curb, with four lanes and a median strip over most of its stretch Sidewalks exist in the commercial core, but are sporadic elsewhere.

The land-use mix in Lafayette is more coarsely grained than in Rockridge, as reflected by some of the parcels near Lafayette's BART station (Figure 3). The retail core transitions to multi-family housing and offices, and then single-family residences There is little mixing within

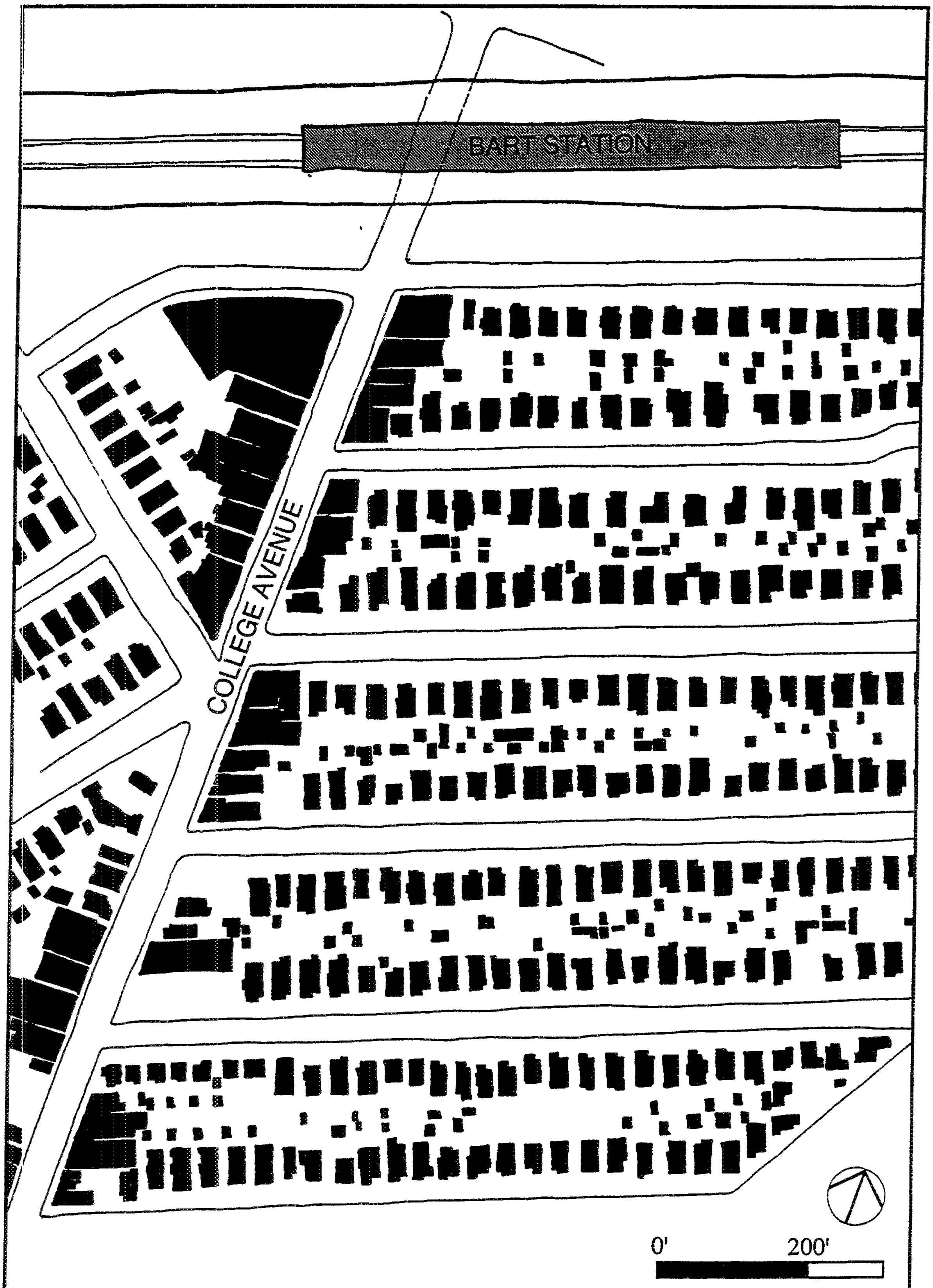


Figure 2. Development Pattern Around the Rockridge BART Station, 1995

Figure 3. Development Pattern Around the Lafayette BART Station, 1995

land-use zones, and no mixing vertically within structures. Retail is configured mainly along Mount Diablo Boulevard as stand-alone buildings with off-street parking fronting the arterial.

As in Rockridge, Lafayette is bisected by State Highway 24, and its elevated BART station lies within the median of the highway. The station is also adjacent to the main retail district, but pedestrian connections are poor due to the elongated block faces and circuitous pathways. Overall, Lafayette's built environment is not particularly inviting to any kind of movement other than by private automobile.

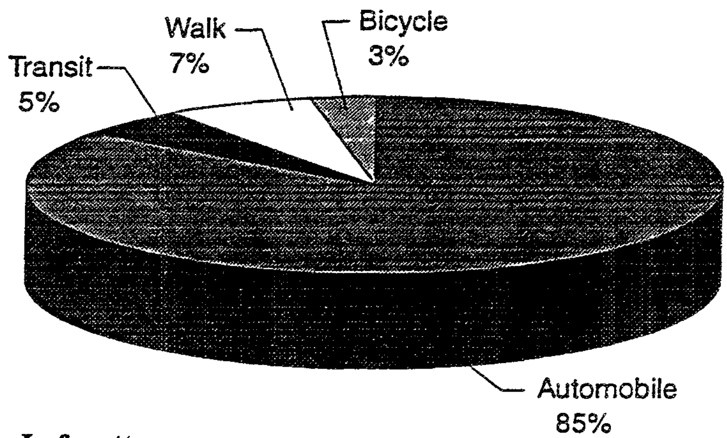
5. NON-WORK TRIP ANALYSIS

5.1 Modal Split Comparisons

Pedestrian-oriented designs and mixed land uses are thought to exert their strongest influence on non-work trips -- in particular, those for convenience shopping and more discretionary purposes. For all non-work trips, including travel for shopping, personal business, recreation, and medical appointments, Figure 4 shows Rockridge residents are far less auto-dependent. They are around five times as likely to go to a store or other non-work destination by foot or bicycle as their Lafayette counterparts This is partly because of the shorter average non-work trip lengths in Rockridge -- 6.8 miles (standard deviation = 12.2) compared with 11.2 miles (standard deviation = 24.0). Shorter trips are largely a product of Rockridge's more compact structure However, even for trips of similar length, Rockridge averaged much higher non-auto shares (Figure 5) For non-work trips of one mile or less, for instance, Rockridge residents made 15 percent fewer auto trips and 22 percent more walking trips than Lafayette residents. For trips of one to two miles, 15 percent were by non-auto means in Rockridge versus just 6 percent in Lafayette.

Among non-work trip purposes, the largest modal split difference was for shop trips -- 19 percent made by Rockridge residents were by a non-auto mode, compared to just 2 percent for Lafayette residents. Walking accounted for 13 percent of shop trips among Rockridge residents; none of the surveyed Lafayette residents walked to shops. Also, 17 percent of social-recreational trips by Rockridge residents were by transit, walking, or bicycling, compared to just 5 percent for their Lafayette counterparts

Rockridge



Lafayette

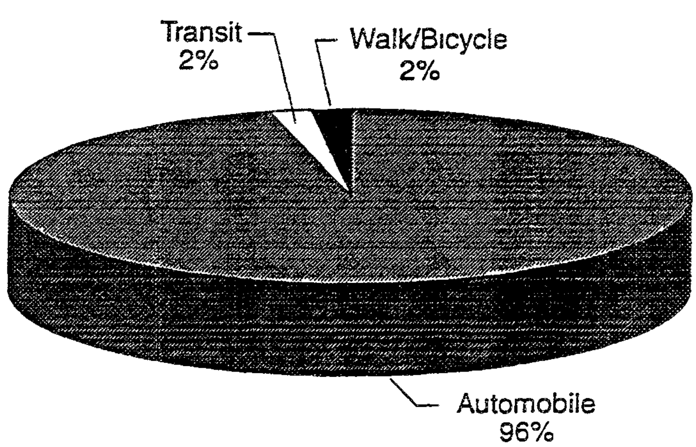


Figure 4. Modal Split Comparison for Non-Work Trips

5.2 Mode Choice Model

A binomial logit model was estimated that predicts the probability of using a non-auto mode for non-work trips as a function of which neighborhood respondents live in as well as other control variables. The resulting model, shown in Table 2, reveals that type of neighborhood exerts a significant influence on mode choice for shopping and other non-work trips The compact, mixed-use, and pedestrian-oriented nature of the Rockridge neighborhood contributes to significantly lower shares of driving trips, balanced by higher shares of walking and transit

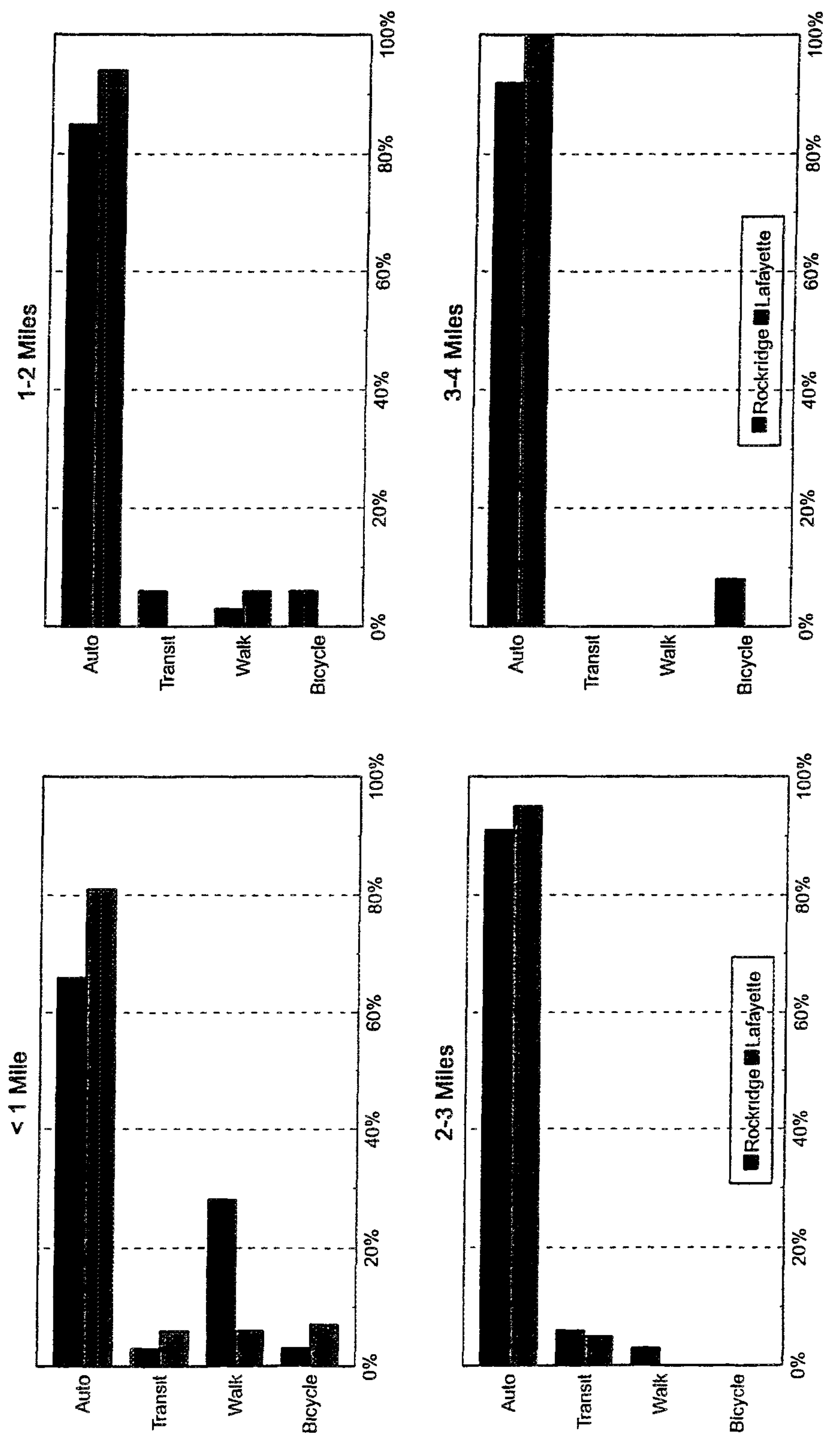


Figure 5. Non-Work Trip Modal Split Percentages, Four Trip Distance Categories

Table 2: Binomial Logit Model for Predicting Mode Choice, Home-Based Non-Work Trips, Rockridge vs. Lafayette

Dependent Variable·
Whether Trip by Non-Automobile Mode
(1=Transit, Carpool, Walking, Bicycling, and Other, 0 = Automobile)

Predictor Variables	Coefficient	Standard Error	Probability
Neighborhood· 0 = Lafayette, 1 = Rockridge	0 8291	.2367	.0039
Persons per household: number of people residing in respondent's household	0.3067	1210	0113
Vehicles per household (cars, vans, and utility trucks)	-0.7798	.2218	0004
Annual salary of respondent (in $10,000s)	-0.0149	.0069	0303
Constant	0 0798	4467	.8583

Summary Statistics

No of cases = 990

ρ^2 [1 - Log Likelihood Ratio of Constant versus Predictors] = 2920

Chi-Square = 219.63, prob. = .0001

Percent of cases correctly predicted = 88 6%
(criterion, if estimated probability > 0.50, predicted mode is non-automobile)

trips. The model also reveals that those living in larger households are more likely to walk, bicycle, or ride transit for non-work purposes. Vehicle availability and higher incomes, on the other hand, reduce the likelihood of traveling by an alternative mode. Overall, the model had reasonably good predictive abilities for a sample of nearly a thousand cases, with a pseudo-R^2 (ρ^2) of .29 and a concordant prediction accuracy of 88.6 percent.

5.3 Simulation

The results of the logit model were used to simulate mode choice based on neighborhood origin and number of vehicles per household (the strongest covariate predictor) Figure 6 plots the results under the assumption that household size equals 2.6 persons (mean value for the two neighborhoods) and annual household income equals $50,000 (near the mean value) The figure shows that the probability of a Rockridge resident without a car available choosing an alternative to driving for a non-work trip is .52, compared to .32 for Lafayette. In both neighborhoods, the propensity to seek an alternative to driving drops sharply with the number of vehicles available. With four cars in a household, the odds of walking, bicycling, or riding transit for a shop trip is less than 1 in 10 in Rockridge, and less than 1 in 20 in Lafayette At the more typical situation of two cars in the households, there is a 10 percent greater likelihood that the non-work trip will be by a non-auto mode in Rockridge than in Lafayette. From this simulation, we can infer that relative compact, mixed-use, pedestrian-oriented neighborhoods average around a 10 percent higher share of non-work trips by foot, bicycle, or transit, controlling for factors like vehicle availability and household income.

6. WORK TRIP ANALYSIS

Physical characteristics of residential neighborhoods are thought to exert less of an influence on mode choice for commute trips and other non-discretionary purposes More important are factors like the comparative prices and travel times among competing modes. Some research has demonstrated, however, that the availability of neighborhood retail can induce transit commuting by enabling transit patrons to shop when walking from bus stops or rail

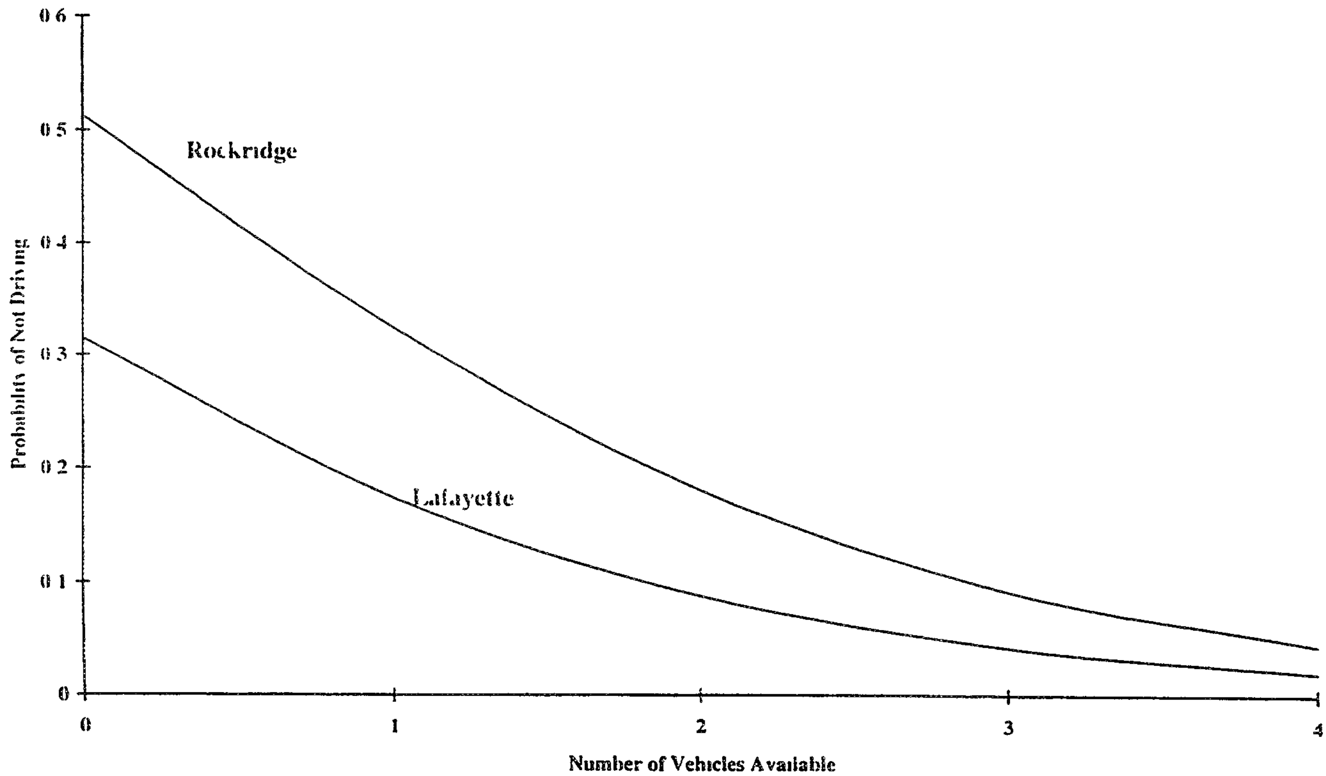


Figure 6. Sensitivity of Non-Work Trips by Non-Driving Modes as a Function of Neighborhood Origin and Vehicle Availability

stations to their homes in the evening. In an analysis of journey-to-work data for eleven metropolitan areas using the American Housing Survey, Cervero (1995) found that having a retail store within 300 feet of one's residence increased the odds of commuting by transit or foot. Frank (1994) similarly found mixed land uses were significantly correlated with higher shares of walking commute trips in the Seattle metropolitan area.

6.1 Modal Split Differences

From our survey of 820 commute trips, Lafayette's residents were found to rely more on their automobiles to get to work than their Rockridge counterparts -- 69 percent solo-commuted versus 51 percent of surveyed Rockridge residents (Figure 7). In both areas, around one in five

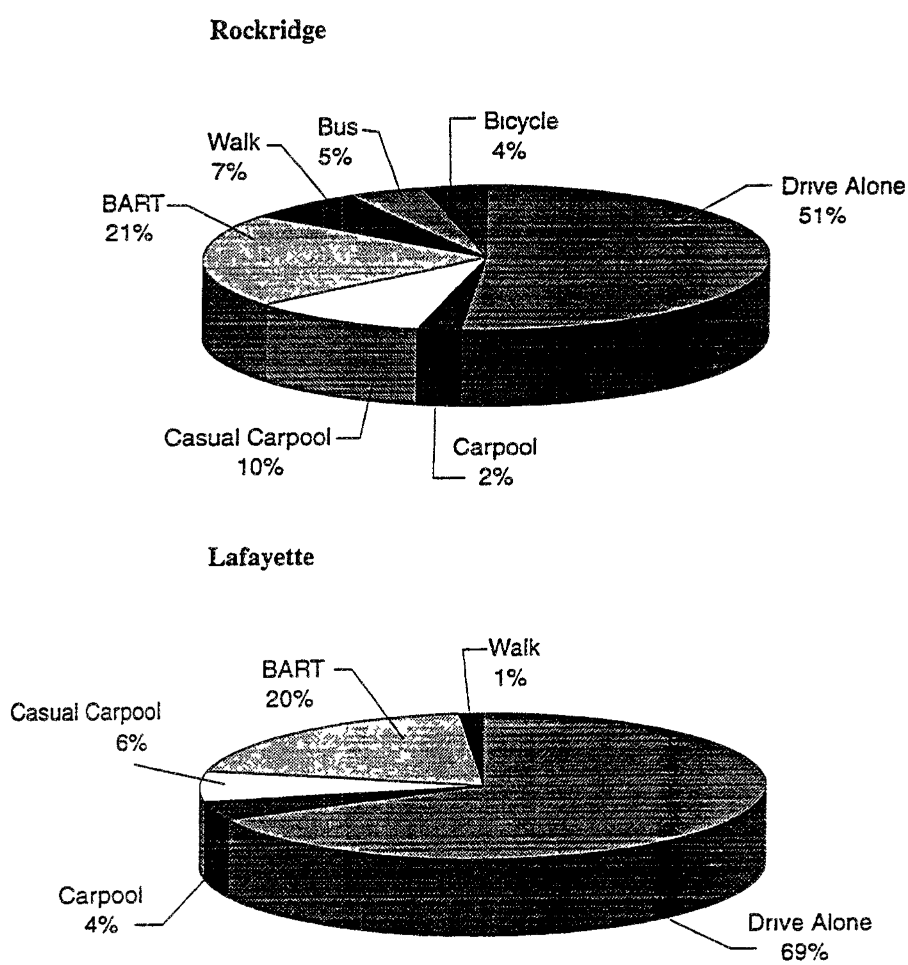


Figure 7. Modal Split Comparisons for Commute Trips

residents reached work by BART. Carpooling was the third most common means of commuting Most ridesharers were "casual carpoolers", a unique phenomenon in the Bay Area wherein people catch rides to San Francisco during the morning commute at designated carpool stops in order to meet the three-occupant requirement of the reserved HOV lane on the Bay Bridge; most casual carpoolers return home in the evening by BART or bus. (The highest rates of rail commuting and casual carpooling were among those who worked in downtown San Francisco -- in the case of Lafayette residents, 54 percent with jobs in San Francisco commuted by BART and 22 percent casual carpooled; for Rockridge, the modal splits were similar) Around 6 percent of Rockridge's employed-residents commuted by bus; none of those surveyed in Lafayette did. Bicycling and walking were also more popular means of getting to work among Rockridge's residents

The greatest modal split differences between the two neighborhoods were actually in terms of the access trips of BART commuters -- 31 percent of access trips to the Rockridge BART station were by foot, compared to only 13 percent of those to the Lafayette station. For both neighborhoods, 94 percent of walk trips to BART stations were under one mile in length. Rockridge's higher incidence of walking access trips clearly corresponds to its more pedestrian-oriented development pattern -- as shown in Figures 2 and 3, the one square-mile surrounding Rockridge's BART station is platted at much finer grain than the one square-mile around Lafayette's station. Rockridge also averaged a 7 percent higher share of bus access trips to BART. In contrast, 81 percent of surveyed Lafayette residents who took BART park-and-rode or kiss-and-rode, compared to just 56 percent of Rockridge BART commuters.

6.2 Commuting Model Choice Model

Table 3 presents a binomial logit model that predicts the probability of commuting by a non-single occupant vehicle (non-SOV). Employed-residents of Rockridge were more likely to commute by some multiple-occupant or non-motorized mode, though the influence of neighborhood type was only statistically significant at around the .20 probability level. As noted, the two neighborhoods produce similar shares of BART commutes, suggesting that neighborhood built environment has little bearing on rail mode choice BART ridership rates are clearly more strongly influenced by regional factors -- e g., regional connectivity of the rail system to large employment centers -- than by neighborhood land-use patterns. This is reflected by the significance of a San Francisco or Berkeley destination (both served by BART) as a predictor of mode choice among the employed-residents of these neighborhoods. In addition to the availability of frequent BART services, factors like expensive parking and congested highways encourage commuters to seek out alternatives to driving alone when heading to large urban centers. Cervero (1994) similarly found that a large employment destination was an important predictor of mode choice among residents of transit-based housing in the San Francisco Bay Area.

As expected, Table 3 reveals that rates of drive-alone commuting increased with vehicle availability and respondent age. Women from both neighborhoods were also more likely to drive

Table 3: Binomial Logit Model for Predicting Mode Choice, Home-Based Work Trips, Rockridge vs. Lafayette

Dependent Variable.
Whether Commute Trip by Non-Single Occupant Vehicle Mode
(1=Transit, Carpool, Walking, Bicycling, and Other, 0 = Non-SOV)

Predictor Variables	Coefficient	Standard Error	Probability
Neighborhood. 0 = Lafayette, 1 = Rockridge	0.2749	0 2134	0.1977
San Francisco Destination (0=no, 1=yes)	3.2448	0 2665	0.0000
Berkeley Destination (0=no, 1=yes)	1.2634	0.2407	0.0000
Vehicles per household (cars, vans, and utility trucks)	-0 3236	0 1266	0.0106
Male respondent (0=no, 1=yes)	0 4549	0 2051	0.0266
Age of respondent (years)	-0.0317	0 0095	0.0001
Constant	0 4537	0 4702	0.3346

Summary Statistics

No of cases = 820

ρ^2 [1 - Log Likelihood Ratio of Constant versus Predictors] = .2912

Chi-Square = 262.20, prob. = 0001

Percent of cases correctly predicted = 78 4%
(criterion, if estimated probability > 0.50, predicted mode is non-automobile)

alone to work. This is consistent with a growing body of research that documents diverging travel patterns between men and women, reflecting the tendency for women to bear a greater share of the responsibility for child care and other domestic chores, and consequently more often require the use of a car (Rosenbloom, 1987). It also likely reflects the higher share of men working in downtown San Francisco's Financial District, a location well served by BART.

It should be noted that the results were not significantly different when other commute mode choice models were estimated, such as formulating the model to predict transit versus non-transit trips or specifying a multinomial model form Apropos the research findings of Cervero (1995) and Frank (1994), this indicates that the presence of finely grained mixed land uses in the vicinity of the Rockridge BART station relative to Lafayette's station did not have a significant bearing on whether someone was more likely to ride a train or bus to work. Neighborhood environment did influence access modes, however the degree of influence could not be modeled because of the limited number of walk access trips to BART in the data base.

7. CONCLUSION

It is significant that the type of neighborhood was a stronger predictor of mode choice for non-work trips than for commute trips. This suggests that at the home-end of a trip, the built environment exerts a stronger influence on trips for shopping, personal business, and other non-work purposes than on commuting. Our research showed that those living in more compact, mixed-use, and pedestrian-oriented neighborhoods, exemplified by Rockridge, average about a 10 percent higher share of non-work trips by walking, bicycling, and transit modes than those residing in a typical middle and upper-middle class American suburb, exemplified by Lafayette (controlling for most other relevant factors, like income, vehicle ownership rates, levels of transit and freeway services, and regional location) These findings, we believe, lend some legitimacy to New Urbanism design concepts.

Neighborhood characteristics were found to exert their strongest effect on local (e.g., less than a mile) non-work trips -- in particular, inducing walk trips as a substitute for automobile trips. Among Rockridge residents, 28 percent of non-work trips under one mile in length were made by foot and 66 percent were by automobile; among Lafayette residents, just 6 percent were by walking and 81 percent were by car. By comparison, differences in transit modal shares among neighborhoods were fairly modest. For the residential ends of trips, the term, "transit-oriented development", is therefore a misnomer of sorts. Transit trips, which are generally longer, non-local trips, are more influenced by regional development characteristics and travel times among competing modes than by the physical make-up of residential neighborhoods. The term "pedestrian-oriented development", on the other hand, more accurately describes the transportation implications of compact, mixed-use neighborhoods that are convenient and pleasing to walk in. Residents of such neighborhoods are at least three times as likely to walk to a store, a nearby restaurant, or local park than their counterparts from neighborhoods that are more spacious and auto-oriented in their designs.

Pedestrian-oriented development was also correlated with significantly higher shares of walking trips to rail transit stations. The Rockridge neighborhood averaged nearly a 20 percent higher share of walking access trips to its BART station than did the Lafayette neighborhood. This research also found that shopping trips made by residents of a pedestrian-oriented neighborhood produced the highest shares of walking trips. This is a somewhat surprising finding in that conventional wisdom holds that consumer shopping is heavily auto-oriented, requiring large amounts of convenient parking. The share of shopping trips using autos by Rockridge residents was nearly 20 percent less than that of Lafayette residents.

Lastly, this research found non-work trips to be much more demand elastic than commute trips, exhibiting more sensitivity to factors such as the number of vehicles in a household. Specifically, vehicle availability had a much stronger negative effect on walking, bicycling, and transit travel for non-work than for work purposes. The relationship between vehicle ownership and non-work travel could very well be interrelated with neighborhood type. In particular, pedestrian-oriented, mixed use neighborhoods might reduce the need to own a second or third family vehicle, which in turn could induce more non-auto trip-making for neighborhood convenience shopping and other more discretionary trips This would be consistent with the findings by Hare (1993) that household vehicle ownership rates are relatively low in compact, mixed-use neighborhoods of Montgomery County, Maryland.

A critical question that remains unanswered by this and other research is whether higher rates of short, within-neighborhood shopping and social-recreation trips by non-auto modes substitute for longer, out-of-neighborhood auto trips, such as to regional shopping centers. Do, for instance, those residing in a pedestrian-oriented neighborhood make fewer trips to large grocery outlets, big-box retailers, and shopping malls, relying on local shops for most of their purchases? Or are walk trips and strolls in pedestrian-oriented neighborhoods simply supplemental, matched by typical rates of auto travel to regional destinations? In order to substantiate the transportation and environmental benefits of pedestrian-oriented development, empirical evidence showing that such neighborhoods average significantly lower rates of auto trips to external non-work destinations will be necessary To uncover such evidence will require a rich travel diary data base which records individual trips made over at least a one week period (since non-work trips to regional destinations like shopping malls are more infrequent). Week-long travel diaries would also need to be compiled for residents of neighborhoods with contrasting built environments, such as Rockridge and Lafayette, or across a whole array of neighborhood types. This, we believe, is a promising area for future research on transportation and built form relationships.

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