# RESOURCE PAPER

# The Effect of Housing Near Transit Stations on Vehicle Trip Rates and Transit Trip Generation

**A summary review of available evidence**

**by**

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## TABLE OF CONTENTS



## APPENDICES

## LIST OF FIGURES



## LIST OF TABLES

## INTRODUCTION: DESCRIPTION OF STUDY PURPOSE

Pursuant to the passage of Proposition 1C (codified as Chapter 27, 2006 (SB 1689)), the Department of Housing and Community Development will provide local assistance for the development of Transit Oriented Development (TODs), more specifically, assistance for developing or facilitating the development of higher density housing uses within close proximity to transit stations. By doing this, it is expected that public transit ridership will increase and private vehicle use will be minimized.

The legislation provides for State Assistance Loans for the development and construction of housing within one-quarter mile of a transit station as well as grants for the provision of infrastructure necessary to support higher density uses within close proximity to a transit station (within one-half mile). A total of approximately $285 million from Prop 1C bond funds will be awarded over a period of three to four years.

1. To be eligible, a proposed Housing Development must:

    a. Be located within one of the following urbanized areas as defined by the U.S. Census Bureau:
        - Antioch
        - Concord
        - Fairfield
        - Fresno
        - Livermore
        - Los Angeles-Long Beach-Santa Ana
        - Mission Viejo
        - Riverside-San Bernardino
        - Sacramento
        - San Diego
        - San Francisco-Oakland
        - San Jose
        - Santa Barbara
        - Santa Cruz
        - Santa Rosa
        - Stockton
        - Tracy
        - Vallejo

        i. b, Have a qualifying Transit Station defined as a rail or light-rail station, ferry terminal, bus hub, or bus transfer station. Included in this definition are planned transit stations whose construction is programmed into a Regional or State Transportation Improvement Program to be completed prior to the scheduled completion and occupancy of the supported Housing Development(s) but in no case more than five years from the application due date. Transit service available along the primary travel corridor from the qualifying Transit Station must:

2. Be within one-fourth mile from a Transit Station, measured in a straight line from the nearest boundary of the Housing Development parcel to the outer boundary of the Transit Station property, and

3. Be within one-half mile from a Transit Station, measured from the Transit Station fare machines to the entrance of the housing unit furthest from the Transit Station fare machines, along a walkable route. The walkable route, after completion of the proposed Project, shall be free of negative environmental conditions, such as barriers; stretches without sidewalks or walking

paths; noisy tunnels; streets, arterials or highways without regulated pedestrian crossing; or stretches without lighted streets.

Eligible Applicants include: Cities, cities and counties, transit agencies, and developers.

Per the proposed evaluation criteria developments assisted pursuant to this program must include at least 15 percent of the proposed housing units affordable to persons of very low and low income for a period of at least 55 years. Eligible infrastructure must be necessary for the development of higher density uses within close proximity to a transit station, or to facilitate connections between that development and the station. Housing developments may include mixed uses consisting of both residential and nonresidential (e.g., retail) activities.

Rating/Ranking criteria for applications must include, but are not limited to:

1) the extent to which the project or development will increase public transit ridership and reduce automobile trips.

2) bonus points for projects or developments that are in an area designated by the appropriate council of governments for infill development as part of a regional plan.

This Resource Paper is intended to clarify and substantiate these criteria, particularly the criteria relevant to item #1.

***Outline of Approach for Estimating Ridership and Vehicle Trip Reduction Benefits of TOD***

In order to show the ridership benefits of TOD, we examined the best empirical information available for adjusting vehicle trip generation rates and estimating transit ridership. Fortunately, a fair amount of empirical evidence has been gathered in California over the past decade on TOD's ridership impacts.

The approach taken parallels somewhat that employed for the Air Resources Board's URBEMIS model that aims to evaluate the potential emission-reduction benefits of smart-growth strategies. The URBEMIS model provides a range of "adjustment factors" for reducing estimated vehicle trip volumes by specific percentages based on characteristics of built environments – including the 3Ds of density, diversity, and design. We propose that the evaluative tool, like URBEMIS, will begin with standard ITE vehicle trip generation rates to estimate the potential reductions in vehicle use a TOD offers compared to a conventional suburban development (the basis of the most use ITE trip rates).

Much research has now been published that suggests either elasticities or "percentage reductions" that might be applied in adjusting vehicle trip rates based on key land use and access factors that have come to be known as the 5Ds: density, diversity, design, destination accessibility, and distance to transit. This Resource Paper attempts to pull together the best empirical evidence available demonstrating how different elements of the 5Ds are associated with two or three key travel-demand metrics: transit modals splits; vehicle trips (per 1000 households); and VMT per household. These are summarized in a matrix format. The matrices for distance to transit are currently stratified by specific mode of transit (e.g., commuter rail; heavy rail; light rail). While introducing different modes helps to refine the analysis, it does so at the expense of creating multiple dimensions and thus greater data demands. Data on the first four Ds is only available at an aggregate level, while data on the 5$^{th}$ D – the crucial effect of distance to transit, is only readily available for the San Francisco Bay Area. Nonetheless, this proved a useful starting point for operationalizing the analysis. An expert panel's informed judgments were used to generalize the findings to all California metropolitan environments and transit modes. The presence of data gaps can serve help guide future research and studies.

Thus, this Resource Paper combines best available empirical evidence with expert judgment to "fill the cells" of the matrices. While many empirical studies are available on built environments and travel, as mentioned earlier, this analysis focuses on relationships in California transit station areas.

***Proposed Evaluation Tool Format and Content:***

1) Standard ITE vehicle trip generation rates will be the starting point for estimating vehicle trip volumes for station-based TODs. Trip rates will be stratified by land uses that are likely to be proposed as part of TODs.

2) Based on the best empirical evidence available, a range of "adjustment factors" for reducing estimated vehicle trip volumes by specific percentages based on the 5D characteristics of built environments, individually and in combinations, was developed.

The literature reviewed for this Resource Paper suggests that Distance to frequent, reliable Transit, along with Density and Destination Accessibility appear to have the biggest impacts on travel behavior for projects in transit environments, while Diversity has a larger impact on non-work trips. Within a quarter- to half-mile walkshed of a transit stop, Design appears to matter somewhat less, at least in influencing the decision of taking transit or not. The influence of urban design and amenities could be indirect, however – such as allowing higher densities to be attained (by "softening" peoples' perceptions of densities) so as to support high-quality transit services. Moreover, design may encourage more pedestrian travel among both transit users and other station area residents and visitors.

Beyond the 5Ds, Transportation demand management (TDM) strategies, such as parking and enhanced shuttle connections, also are known to influence travel behavior. How such TDM measures interact with the 5Ds (individually and collectively) to shape transit usage in and around stations has received little empirical attention to date. In this regard, the views and inputs from the panel of experts proved of value, in that they suggested that many such TDM measures are correlated with the density of transit station area's catchment area. This is an area for further research.

3) Based on these data, matrices were developed for modifying the ITE vehicle trip generation rates for potential TOD projects. It is recognized that some cells contain provisional values, reflecting knowledge gaps. A separate step to estimate increased transit ridership generated by TOD projects was also devised, as this is also a legally mandated transportation criterion for evaluating Proposition 1C TOD proposals.

### *Expert Research Panel Meeting*

A draft of this Resource Paper was sent to a panel of experts (representing both the research community and California's four largest MPOs; see Appendix C). A meeting of this panel took place on August 20, 2007 in Oakland to discuss, refine and validate the methodology. In a quasi-Delphi format, the panel reviewed and discussed the proposed trip rate adjustments, and through group discussions suggested changes and refinements and identified further studies and data of value. The views of the Expert Research Panel on how the 5Ds might interact with TDM strategies like parking management to influence travel behavior were also solicited. In the end, a plausible range of adjustment factors was agreed upon for specific types of TOD settings in California.

## SUMMARY OF THE LITERATURE REVIEW

### *Theory and Background on the 5-Ds and Transit Oriented Development*

The beginnings of the 5-D analysis methodology lie in research by Robert Cervero[1]. This original research found that certain characteristics of the neighborhood around a household affected the number of vehicle trips and vehicle-miles traveled generated by that household. This effect was independent of household characteristics (income, household size, number of workers, etc.) typically used in vehicle trip generation equations. Related research has found that 5-D factors also promote transit ridership when they occur near rail transit stations.

The trip generation step in traffic impact analyses should therefore include an adjustment of household-based trip-generation rates to reflect the characteristics of the area surrounding the household. In fact the ITE *Trip Generation* manual has been recommending such an adjustment for its last three editions. Presently, the Transit Cooperative Research Program (TCRP) project H-27A ("Ensuring Full Potential Ridership from Transit-Oriented Development") is being conducted to develop such trip-rate adjustments. TCRP H-27A has compiled driveway tube counts for 17 multi-family housing projects near rail stations in the San Francisco Bay Area and San Diego County and its findings will be available sometime in 2008 to further refine the data presented in this resource paper.

Development near transit that is higher density has an appropriate diversity of land uses in an environment designed for easy walking and biking reduces auto use for several interrelated reasons:

Better regional accessibility – especially via high-capacity transit, reduces auto commuting

[1] Cervero, R. and K. Kockelman (1997) "Travel Demand and the 3Ds: Density, Diversity, and Design," *Transportation Research D*, Vol. 2, pp. 199-219

- More local opportunities lessen need for auto dependence
- Diversity of uses near transit stops encourages station-area residents to ride transit by allowing "trip chaining" (i.e., walking to nearby shops en route to residences from stations after work).

There will also be reduced vehicle trips and vehicle miles of travel due to:

- Fewer autos owned
- More trips by walking
- Shorter auto trips

It is noteworthy that many TOD proponents point to benefits beyond transportation. For example, local shops and services would provide a benefit to residents even if they do not use transit

***The 5-D TOD Characteristics Explored for the Trip Rate Adjustment Model***

The literature on neighborhood characteristics that affect trip generation is evolving over time and may definitions still vary from study to study. The variables described below define the 5Ds.

*Net Residential Density* – This variable is measured in units of dwelling units per residential acre. The acreage should include not only land zoned and devoted to residential uses but also associated pocket parks and local streets, but exclude large parks, open space, lakes, steep slopes, and off-site non-residential uses. This matches the practice in general plans where areas designated for residential development typically show large non-residential features separately but typically do include acreage that will be devoted to local streets and neighborhood amenities. Research suggests that, all else being equal, denser developments generate fewer vehicle-trips per dwelling unit than less dense developments.

*Jobs/Housing Diversity* – Research suggests that having residences and jobs in close proximity will reduce the vehicle-trips generated by each by allowing some trips to be made on foot or by bicycle. This variable measures how closely the neighborhood in question matches the "ideal" mix of jobs and households, which is assumed to be the ratio of jobs to households measured across the region as a whole.

*Walkable Design* – Many pedestrian and bicycle improvement projects are based on the assumption (supported by some research findings) that improving the walking/biking environment will result in more non-auto trips and a reduction in auto travel. The difficulty with using this variable in an equation is that there are many factors that influence the pedestrian experience and it is difficult to come up with a single definition that captures them all. It has also been found that the data required to specify the design variable is often either not available or would be expensive and time-consuming to obtain. In any case, the design variable when isolated usually has the weakest influence on the overall adjustment of the D factors, though it also seems to have important synergistic effects in conjunction with density and diversity.

*Destinations* – Research shows that, all else being equal, households situated near the regional center of activity generate fewer auto trips and vehicle-miles of travel. When comparing different potential sites for the same type of development, this variable is very important.

*Distance to Rail Mass Transit Station* – If a site is located near a rail transit station, research indicates that further reductions in the automobile trip-generate rate are warranted. In general, transit ridership rates among station-area residents increase exponentially as the distance to a rail station declines. This is documented in a recent and comprehensive study of TODs in California[2].

***Distance to Transit – The Fifth and Foremost D: Summary of Findings of Lund, Willson, Cervero Study of TOD and Ridership in California***

*Travel Characteristics of Transit-Oriented Development in California* gauges the ridership bonus of TOD residency in California, followed by statistical modeling of factors influencing residents' mode choices and before-and-after comparisons of travel behavior. The work builds upon an earlier study of transit ridership among households located near rail stations in California's five largest metropolitan areas.[3] Both studies found that the fifth D – Distance to Transit -- the most influential "D" in increasing transit ridership and reducing vehicle use. Lund et al's (2004) analyses draw upon a database on travel and other attributes of

[2] Lund, Cervero, Willson, (January 2004), *Travel Characteristics of Transit-Oriented Development in California*

[3] Cervero (1993), *Ridership Impacts of Transit-Focused Development in California*. Berkeley: Report to the California Department of Transportation, IURD Monograph.

nearly 1000 residents living in 26 housing projects within ½ mile of California urban rail stations who were surveyed in 2003 The 26 surveyed housing projects were served by a variety of rail services: heavy rail (i.e., powered by a high-voltage third rail in an exclusive right-of-way) in the San Francisco Bay Area and Los Angeles; light rail (i.e., powered by overhead electrical wires) in Los Angeles, San Diego, and Sacramento; and commuter rail (i.e., diesel-electric locomotion) serving the San Francisco-San Jose axis, northern San Diego County, and Los Angeles-Orange County.

**Findings on the Ridership Bonus of TOD.** Based on one-day travel diaries completed by adult residents of the 26 surveyed TOD housing projects, the mean share of commute trips by transit was 27 percent. This figure was compared to those living in a "donut": an area between ½ and 3 miles of a station. The mean share of commute trips via transit among those residing in the donut was 7 percent. Thus, those living within ½ mile of a rail stop were around four times as likely to rail-commute as those living within a distance more oriented to bus access (i.e., ½ to 3 miles). And when compared to those living beyond 3 miles but within the same city as the housing projects under study, the differential in transit commute shares was six-fold.

Analysis and modeling by Cervero (2006) of the survey data collected by Lund et al suggests local policy-makers have fewer levers available to influence transit riding among station-area residents than regional policy-makers. Local officials can control land uses around stations, however these variables had minimal explanatory power. Regional agencies, on the other hand, are in a position to introduce measures that encourage employers to promote transit (e.g., underwriting the cost of transit passes) and discourage car commuting (e.g., eliminating free parking) – both "workplace policy" variables were significant predictors. California has considerable precedence in this regard under the "Employer Commute Options" initiatives mandated by Federal and State clean-air legislation in the 1990s; today, such employer-based policies are largely voluntary.

The findings of Lund et al and Cervero confirm that when it comes to transit-based residences, the greatest ridership pay-off comes for intensifying station-area housing. While streetscape improvements, parking provisions, and other physical-design elements might influence the attractiveness of station-area housing among prospective tenants, such factors appear to exert minimal influences on whether station-area residents opt for transit or not. It is housing supplies, not station-area designs and parking levels, which are the strongest localized factors influencing ridership in neighborhoods abutting rail stations in California. Moreover, studies suggest that high ridership among those living near California rail stations is significantly a product of "self selection" – for lifestyle reasons (e.g., the desire to rail commute instead of drive to work), some households purposely move into residences that are convenient to high-quality transit (Cervero 2007). Using data from the San Francisco Bay Area, Cervero (2007) estimates that around 40% of the change in the odds-ratio of rail commuting among station-area residences can be attributed to residential self-selection. The policy implications of this finding is that local officials should seek to zone land, set building codes, and provide local services so that market-responsive housing products are built near California rail stations.

The finding that urban design factors have relatively minor influence on transit riding within a walkshed of rail stations suggests the presence of an "indifference zone": for those living within a half-mile or so of a station, they will generally ride transit regardless of local urban design features, as long as there is a safe walkable route to the station. On the other hand, out-of-neighborhood attributes, like job accessibility and street connectivity at the destination, have a significant bearing on transit usage (Cervero 2006).

***Quantifying the Effects of Proximity to Transit: A Keystone Study by MTC***

In *Characteristics of Rail and Ferry Station Area Residents in the San Francisco Bay Area (2006)* the San Francisco Bay Area Metropolitan Transportation Commission studied existing Transit Oriented Development (defined as development within a one-half-mile *walking* distance of a rail or ferry terminal. Demographic and travel data were from MTC's 2000 Household Travel Survey. This survey compiled

travel and demographic data for some 35,000 individuals age 16 years and above residing in nearly 15,000 Bay Area households.

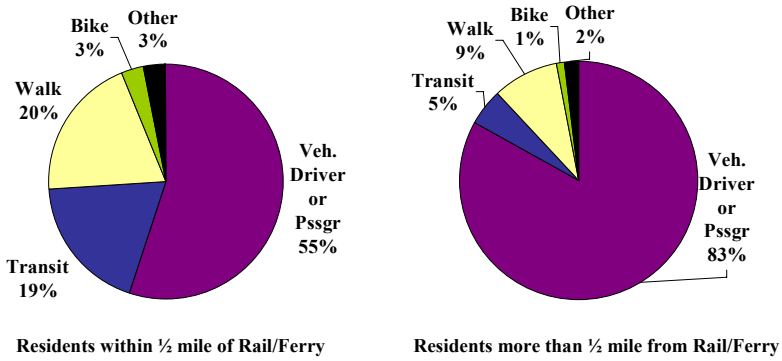
Extensive analysis of this large Bay Area data base reveals that people living within a half mile of a transit or ferry station are four times more likely to use transit than those living more than a half mile from a transit or ferry station. This more or less confirms the findings on variation in modal splits by distance to transit found by Cervero (1994) and Lund et al. (2003). The Bay Area survey results show that residents living and working within a half mile of transit or ferry stations average 42% of their daily trips by transit, walking or biking (see Figure 1). Nearly a third of households within a half mile of ferry or transit stations have no vehicle. Households within a half mile of ferry or transit stations generate half the VMT of suburban and rural residents.

Figure 1 also indicates that residents within a half mile of a rail station or ferry terminal have a vehicle mode share 28 percent lower than for the region as a whole. The same data also indicate that the transit mode share of residents increased by 14 percent. This suggests that about half of the reduction in vehicle trips observed for station/terminal area residents may be attributed to the substitution of transit for private vehicle trips.

**FIGURE 1: MTC Findings for ½ Mile around Rail/Ferry**

MTC Findings for ½ mile @ Rail/Ferry:
Vehicle use one-third lower
All Non-auto Modes Increase Substantially

Mode Shares for All Types of Trips




***MTC Study Method***

Using Geographic Information Systems (GIS), BATS2000 households and residents were parsed into groups based on the household's proximity to rail and ferry stations in the Bay Area (the report's Volume II, Appendix G contains a detailed discussion of the GIS methodology). Only stations or stops that existed in the year 2000 (the year the BATS survey was administered) were examined. The seven rail and ferry operators included in this study are:

1) Altamont Commuter Express (ACE) stations,
2) Amtrak stations,
3) Bay Area Rapid Transit (BART) stations,
4) Caltrain stations
5) Ferry terminals (excluding Alcatraz Island ferries and seasonal ball park ferries),
6) San Francisco Municipal Railway (MUNI light rail lines and cable car stops), and
7) Santa Clara Valley Transit Authority (VTA) light rail stations.

Geographic areas (or buffers) were created around each rail and ferry stop in the Bay Area (in the case of MUNI, buffers were created around the light rail lines). The buffers were created around rail/ferry stops to create three distance categories: within ½ mile, ½ mile to 1 mile, and greater than 1 mile. Households were then placed into one of the three distance categories based on the location of the household with respect to the nearest rail/ferry stop. Households beyond one mile from a rail/ferry station were further disaggregated by population density, which was determined using Census 2000 block group data. The four population density categories along with examples of cities and communities for each group were as follows:

1) Urban 10,000 or more persons/square mile e.g., San Francisco, Berkeley, Oakland
2) High-Suburban 6,000 to 9,999 persons/ square mile, e.g., Palo Alto, Vallejo, Richmond, San Leandro
3) Low-Suburban 500 to 5,999 persons/ square mile, e.g., Lafayette, Walnut Creek, Sausalito
4) Rural Less than 500 persons/square mile e.g., Oakland Hills, Point Reyes Station, Guerneville

Since the station areas studied vary from ferry terminals with fewer than ten daily departures to BART and Muni light rail (with average headways under 15 minutes at most stations and major stops) the results are truly a composite – a theoretical "average" transit station. MTC also conducted some mode specific analysis, which is summarized in Table 1 and Figure 2 below. Detailed mode split data, used to estimate vehicle trip reductions in TODs surrounding various rail modes, is found in Appendix A.

The important finding: TOD residents living around high frequency rapid rail (BART or Muni LRT) stations exhibit 50% fewer vehicle trips compared to the region. Commuter rail and VTA light rail station area residents appear to make vehicle trips at rates more comparable to the rates observed for region as a whole; residents living within ½ mile of a VTA station do make significantly more transit trips compared to the region as a whole (nearly 50 percent more); within ¼ mile of VTA, residents make more than twice as many trips by transit as the regional average.

**TABLE 1: Effect of Transit Proximity by Mode**
Vehicle Trip Reduction Factors and Transit Increase Factors by Transit Operator/Mode
Calculated as Station Area Mode Share ÷ Regional mode share
(First factor in each cell is for within ¼ mile circle; second is for ¼ – ½ mile band
See Appendix A for Data and Calculations)

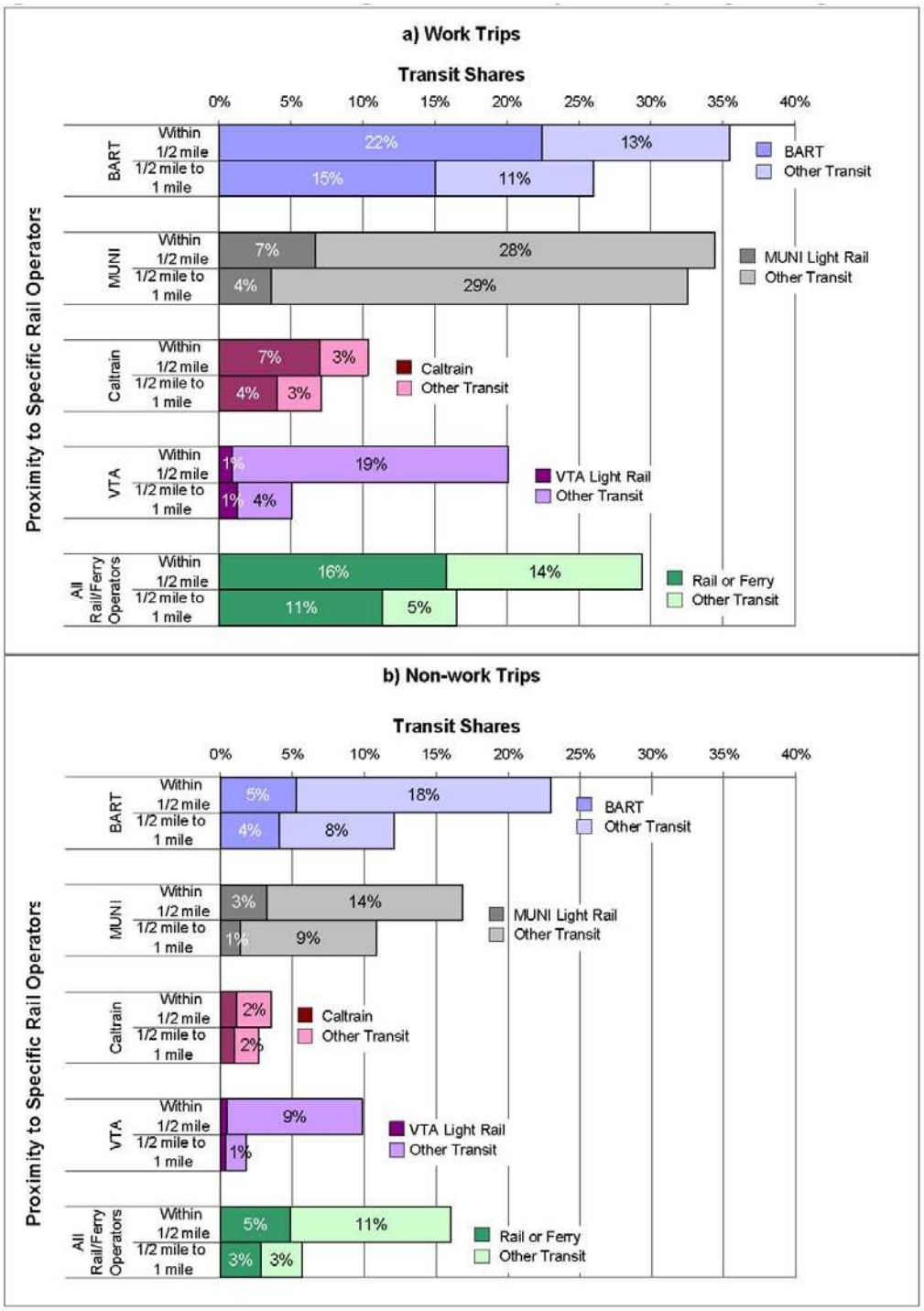
| **BART (Rapid Rail)** | **Caltrain (Commuter Rail)** | **SF Muni (Light Rail)** | **VTA (Light Rail)** |
|---|---|---|---|
| Vehicle Trip Rate Reduction Factor: | Vehicle Trip Rate Reduction Factor: | Vehicle Trip Rate Reduction Factor: | Vehicle Trip Rate Reduction Factor: |
| **0.63 \| 0.57** | **1.03 \| 1.10** | **0.58 \| 0.64** | **0.94 \| 1.04** |
| | | | |
| Transit Trip Rate Increase Factor: ¼ mile: \| ¼ – ½ mile | Transit Trip Rate Increase Factor: | Transit Trip Rate Increase Factor: | Transit Trip Rate Increase Factor: |
| **3.16 \| 3.56** | **1.01 \| 0 .74** | **3.22 \| 3.61** | **2.40 \| 0.55** |

The effects are shown to vary by mode, with the most marked effects observed around rail systems with high frequency service that includes direct service to the region's major transit-oriented employment and service center, downtown San Francisco, i.e., BART and Muni. Somewhat ironically, BART and MUNI exhibit a higher transit trip rate increase factor, and MUNI lower vehicle trip rates, in the ¼-mile to ½-mile band versus the immediate ¼-mile station buffer. The differences are minor, and the authors recommend that for services with comparable frequencies and system-wide access to regional destinations, there may not be a need to distinguish between the first and second ¼-mile rings.

For VTA, whose light rail lines came within ¼ mile of approximately 7 square miles of Santa Clara County in 2000 (about two percent of its urbanized service area of 326 square miles at that date), the first ¼ mile ring appears to be more productive of transit trips (and, reductive of vehicle trips) compared to the second ring. The ¼-mile circle is also more productive/reductive (though to a much lesser degree) for Caltrain, which in 2000 had peak frequencies of over 20 minutes and hourly headways through much of the day.

The authors believe these systems roughly bracket the range of rail transit modes in California. *There is a need to fill in the gaps with data for other rail systems in the state, and well as for high-frequency bus hubs zones that are also eligible for TOD housing grants.*

**FIGURE 2: Work and Non-Work Trip Transit Shares by Proximity to Specific Operators (MTC 2006)**




Source: Bay Area Travel Survey 2000

In response to questions regarding how the Bay Area compares to the rest of the State of California, MTC extended the analysis, performing a statewide analysis of all transit (rail and ferry) stations. This was limited to journey to work data from the US Census, which asks approximately one-in-eight households about commute behavior, but not about non-work trips. (Each of the four major MPOs conduct a household survey which does ask about non-work trips, but the format and survey year vary too significantly for the other MPOs travel surveys to permit easy comparisons).

The MTC comparative analysis indicates that the drive-alone mode share of work trips is approximately one-third lower within a half mile of a transit station compared to the regional/statewide average. This holds true both within the MTC region and for the remainder of the state. Transit ridership also increases by comparable proportions.

This leads to an important conclusion: *Assuming relationships between commute and non-work travel observed in the Bay Area hold elsewhere, this comparative analysis suggests that the Bay Area data can be applied elsewhere in the state.*

### *The Effectiveness of the Other 4Ds: Consensus Results*

In 2001 Fehr & Peers, under contract through Criterion Engineers and Planners to the US EPA, developed a literature synthesis and a methodology for estimating travel demand impacts from land-use and urban design changes. The methodology uses a set of elasticity factors that relate a neighborhood's built environment characteristics and regional accessibility to the amount of vehicular travel generated in the neighborhood. These factors are used to compute the percentage change in vehicle trips (VT) and vehicle miles traveled (VMT) resulting from different land-use plans and urban designs.

The methodology was developed by Fehr & Peers Associates under contract to Criterion Planners/Engineers for use in Criterion's INDEX models, including the U.S. EPA version known as Smart Growth INDEX.

### Research Approach

The 4D method is based on research into the relationship between land-use and travel behavior. Nationally, over forty studies were reviewed; each of the studies examine how changes in land-use characteristics, such as density, relate to changes in travel generation was measured by vehicle trips and vehicle miles of travel. The bibliography of the research is included as Attachment A.

Using this research data, a 4D traffic analysis method was developed in three steps as follows:

1) Elasticities were derived between vehicular travel (VT and VMT) and primary descriptors of the built environment and accessibility for each study whose research provided valid, comparable results. An elasticity is a measure of the percentage change that occurs in a dependent variable (VT or VMT) as a result of a percentage change in an influential variable (density, diversity, design or destinations). For example, if vehicle trips increase by 0.1% for each 1% increase in development density, then vehicle trips are said to have an elasticity of 0.1 with respect to density. If vehicle trips *decrease* by 0.05% for each 1% increase in density, then vehicle trips are said to have an elasticity of -0.05 with respect to density.

2) Individual study results were synthesized into a unified matrix of partial elasticities. These express percentage changes in VT and VMT as a function of percentage changes in each of the 4Ds. The 4Ds are expressed in terms of: 1) density (population and employment per square mile); 2) diversity (the ratio of jobs to population); 3) design (pedestrian environment variables including street grid density, sidewalk completeness, and route directness); and 4) destinations (accessibility to other activity concentrations, expressed as the mean travel time to all other destinations within the region, e.g. a location within the

regional core will ordinarily have a higher 'destinations' rating than a location on the fringe of the urban area, because the central location offers greater accessibility to a higher percentage of the region's employment).

3) Creation of a table of elasticities for assessing the relative benefits of one land-use pattern compared with another.

In 2003, these synthesis values were updated using a Delphi Panel. The tables below present the results of the Delphi Panel survey's recommendations regarding the 4D elasticities, i.e., the 4 Ds apart from Distance to rail transit or other transit with performance characteristics similar to urban rail transit:

**TABLE 2: Delphi Panel Consensus Elasticity Values for the 3 Ds[1]**

| | **Vehicle Trips$_{total}$** | **Vehicle Miles Traveled (VMT)$_{total}$** |
|---|---|---|
| | **Recommended Value** | **Recommended Value** |
| Residential Density | -0.05 | -0.11 |
| Diversity | -0.07 | -0.12 |
| Design | -0.03 | -0.09 |

Note
1. For use when relative regional accessibility between study sites cannot be estimated or is constant.

**TABLE 3: 2003 Delphi Panel Consensus Elasticity Values for the 4 Ds[2]**

| | **Vehicle Trips$_{total}$** | **Vehicle Miles Traveled (VMT)$_{total}$** |
|---|---|---|
| | **Recommended Value** | **Recommended Value** |
| Density | -0.04 | -0.05 |
| Diversity | -0.06 | -0.05 |
| Design | -0.02 | -0.04 |
| Destination Accessibility | -0.03 | -0.20 |

Note:
2. For use when relative regional accessibility between study sites can be estimated or is not constant.

Using the data in Table 3 is straightforward once the relevant D variable is calculated. For example, if a project is twice the prevailing density in the station area, it would produce 4 percent fewer vehicle trips per unit.

With respect to transit trip production, analysis by Ross and Dunning (1997) of the 1995 National Personal Transportation Survey (NPTS) suggests that about one-third of the vehicle trip reduction in denser urban areas compared to less dense areas translates into new transit trips. As noted above in the discussion of Figure 1, MTC data for 2000 suggests that in station areas there ratio of new transit trips produced to auto trips reduced is greater, i.e., about one-half. The consensus of the Expert Panel was to use the MTC ratio. Thus in the example in the preceding paragraph, two percent of the eliminated vehicle trips would translate to new transit trips. The other two percent would be attributable to other modes, e.g., walking.

The studies reviewed in 2001 used a variety of definitions of the 4Ds; the 2003 Delphi Panel update standardized the definition for the study participants: these standard definitions are presented in Table 4.

**TABLE 4:**
**D-Variable Definitions for Tables 1 and 2**

| | | |
|---|---|---|
| **Density** | = | Percent Change in [(Population + Employment) per Square Mile] |
| **Diversity** | = | Percent Change in {1 - [ABS(b * population - employment) / (b * population + employment)]} |
| where: | | *b* = regional employment / regional population |
| **Design** | = | Percent Change in Design Index (see below) |
| **Design Index** | = | 0.0195 * street network density + 1.18 * sidewalk completeness + 3.63 * route directness |

where:

*street network density* = length of street in miles/area of neighborhood in square miles

*sidewalk completeness* = length of sidewalk/length of public street frontage

*route directness* = average airline distance to the neighborhood center/average road distance to the neighborhood center

**Destination Accessibility** = Percent Change in Gravity Model denominator for study TAZs "i": Sum[Attractions(j)*Travel Impedance(i,j)] for all regional TAZs "j"

***Review of Recent Literature***

For this Resource Paper, more than 200 studies were reviewed with an eye toward updating these consensus elasticities. These are listed in the appended Bibliography; About half of the more relevant studies have been included in an annotated bibliography, also appended. Studies that address the themes of interest (TOD area vehicular trip generation, transit trip generation, and elasticities associated with the 5Ds generally) were examined in detail. Most of these studies are based on relationships in urban settings outside of California, an appreciable share are drawn from California's five largest metropolitan areas.

While there have been many newer studies, apart from the studies discusses above by Cervero (1993), Lund et al (2003), and MTC (both of which are primarily concerned with the effects of distance to transit), the new studies tend to reinforce the direction and magnitude of the effects of the other four Ds. Relevant findings of studies that address the 5Ds and travel variable elasticities associated with the 5Ds are summarized in Appendix B. Again, based on the review of the current authors, there is support for the direction and general magnitude of the elastiticies listed in Table 3 above. Neither the authors nor the Expert Panel found any compelling reasons to change these consensus values.

***Findings of the Expert Research Panel***

A draft of this Resource Paper, *The Effect of Housing Near Transit Stations on Vehicle Trip Rates and Transit Trip Generation: A Summary Review of Available Evidence* (August 10, 2007 v2), was prepared and distributed for review by a panel of researchers and transportation modelers, referred to as the "Expert Research Panel". Panel members and their affiliations are listed in Appendix C.

This Expert Research Panel was called together to discuss the findings of a draft and further refine the vehicle trip rates and transit trip generation information in support of the development of a spreadsheet model. This spreadsheet model, to be subsequently developed by the researchers through a Caltrans contract with California PATH, will be used to calculate the relative benefits as they relate to reduced auto trips and increased transit ridership of proposed projects applying for TOD Program funding.

The Expert Research Panel, in a session facilitated by Judith MacBrine of Caltrans, and using a modified Delphi process, reached a working consensus on the following items. These will be incorporated into the evaluation method embedded in the model

**Item 1:** There is insufficient basis to warrant distinguishing between residential Transit-Oriented Developments located within a quarter-mile of a transit station and a half-mile of a transit station.

**Item 2:** The relative impact of TODs on standard ITE rates is as shown in Table 5 below:

**TABLE 5:**
**Expert Panel Recommendations of Vehicle Trip Reduction by Mode and Station Vicinity Density**

| **Vehicle Trip Rate →** <br><br> **↓ Transit Mode** | **Low Density** | **Medium Density** | **High Density** |
|---|---|---|---|
| Heavy Rail (e.g., electrified 3rd Rail: BART, METRO) | 80% | 63% | 50% |
| Light Rail | 95% | 80% | 60% |
| Bus Rapid Transit (BRT) | 95% | 80% | 65% |
| Rapid Bus/Express Bus | 99% | 90% | 80% |
| Commuter Rail, (e.g., Capitol Corridor, Caltrain, Metrolink, Surfliner) | 97% | 90% | 85% |
| Ferry, Non-Express Bus Hub | 97% | 90% | 85% |

Example: If 100 vehicle trips were typically expected from a housing development in high density location, then location of that housing development as a TOD within one-half mile of a BART station (heavy rail) would result in a 50 percent reduction of vehicle trips (or 50 vehicle trips).

**Item 3**: High, Medium and Low Densities will be determined by measuring the gross density within a four-mile radius of the transit station. Density will be measured as gross residential population divided by square miles of land (excluding water). All Census 2000 census blocks with any portion falling within the four-mile radius will be included in this calculation.

Based on analysis of California station-areas, it is anticipated that the density ranges will be:

- High Density: 7,500+ residents per square mile.
- Medium Density: 4,500 to 7,499 residents per square mile.
- Low Density: <4,500 residents per square mile.

Additional data will be reviewed to determine whether the resident per square mile values should be further adjusted.

The four-mile radius measurement is based on research by Cervero and Duncan (2006). This research indicates that the balance point for a vehicle reduction shed is a four-mile radius rather than a two-, three- or six-mile radius.

**Item 4:** Additional adjustments based on elasticity values can be made for the following, subject to adjustment relative to measurement feasibility:

- Residential Density: -0.04.
- Diversity: -0.06
- Design (re: pedestrian and bicycle): -0.02.

**Item 5:** The increase in transit ridership would be identified as 50 percent of the reduction in vehicle trips. In the above example of a TOD at a BART station within a high density location, the TOD would be projected to generate 25 transit trips.

Other General Comments by the Expert Research Panel on the Proposed TOD Program Guidelines:

- The definition of “bus hub” (which in the statute) should be refined
- Transit service quality is important.
- There may be a sixth ‘D” to consider: demographics (ethnicity, income, and years in U.S. for immigrants)?
- Parking policies and unbundled parking are critical components to successful TODs.

***Summary and Recommendations***

(1) The tool will apply the TOD vehicle trip factors for the appropriate transit mode and station vicinity per Table 5). This effectively covers the most important D factor – Distance to Transit – and also serves as a surrogate for the regional Destinations accessibility variable.

(2) Next, the tool will apply elasticity factors for density, diversity and design as summarized in Table 3 and as defined in Table 4. The elasticity should be applied to the ratio of the proposed projects value versus that of the entire half-mile station area. These adjustments will be applied to the extent that it is feasible to quantify these values using data available to all applicants.

(3) Finally, factors beyond the 5Ds, such as TDM measures, that might further increase transit ridership or decrease vehicle trips, will be noted qualitatively.

**A Hypothetical Example of Method as Envisaged:**

*Project:: A 150-unit multifamily housing development at a Light Rail Station in a high-density area*

**Vehicle Trip Reduction:**

| | |
|---|---|
| (Unadjusted) ITE vehicle trips projection: | 900 daily vehicle trips |
| Apply vehicle trips reduction factor: | .60 x 900 |
| Result after application of 5th D factor: | 540 vehicle trips (-360) |

*Then apply additional factors for the station area:*
(From Table 3)

Assume that the Project:

| | |
|---|---|
| Density = 2 x the ½ mile TOD average: | -4% reduction → -22 vehicle trips (4% of 540) |
| Diversity measure increases by 100%: | -6% reduction → -32 vehicle trips (6% of 540) |
| Design Index increases by 100% | -2% reduction → -11 vehicle trips (2% of 540) |
| Total Vehicle Trip Reduction: | -360 - 22 -32 -11 = -425; |
| Resulting Vehicle Trips: | 900 – 425 = 475 vehicle trips |

**Transit Trip Increase:**

| | |
|---|---|
| Assume 1/2 of Vehicle trip reduction from other 4Ds represents additional transit trips | 1/2 x (-425) → -212 |
| Resulting Transit Trip Generation: | 212 new daily transit trips |

Following the process outlined above, credits would be applied for TDM measures such as parking charges, parking management, or frequent shuttle services.

# APPENDIX A: MODE SHARES, AND VEHICLE AND TRANSIT TRIP RATES (MTC)

**TABLE A-1: Mode Shares and Calculated Vehicle Trip Reduction and Transit Trip Increase Factors – BART Rapid Rail**

***CIRCULAR BUFFER ANALYSIS***

| | Proximity of Resident's Home to **BART Stations** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Within | 1/4 mile to | 1/2 mile to | Greater than 1 mile | | | | |
| Travel Characteristic | 1/4 mile | 1/2 mile | 1 mile | Urban | High-Sub | Low-Sub | Rural | Total |
| MODE SHARES | | | | | | | | |
| *Home-Based Work* | | | | | | | | |
| **In-Vehicle Person** | **49.4%** | **47.9%** | **63.3%** | **79.1%** | **89.1%** | **88.8%** | **94.0%** | **81.7%** |
| Vehicle Driver | 42.9% | 36.2% | 55.7% | 71.3% | 82.5% | 83.4% | 88.6% | 74.9% |
| Vehicle Passenger | 6.5% | 11.7% | 7.6% | 7.7% | 6.6% | 5.3% | 5.5% | 6.8% |
| **Total Transit** | **39.2%** | **28.7%** | **25.1%** | **14.6%** | **7.4%** | **7.2%** | **4.0%** | **12.2%** |
| BART | 31.3% | 18.8% | 11.7% | 3.4% | 2.6% | 3.9% | 1.4% | 5.1% |
| Other Transit | 8.0% | 9.9% | 13.4% | 11.2% | 4.8% | 3.3% | 2.6% | 7.0% |
| **Bicycle** | **0.8%** | **6.2%** | **2.6%** | **1.3%** | **1.3%** | **1.7%** | **0.5%** | **1.8%** |
| **Walk** | **8.7%** | **15.4%** | **6.9%** | **3.5%** | **1.8%** | **1.8%** | **1.2%** | **3.4%** |
| **Other** | **1.9%** | **1.8%** | **2.2%** | **1.4%** | **0.4%** | **0.5%** | **0.2%** | **1.0%** |
| *Non-Work Trips* | | | | | | | | |
| **In-Vehicle Person** | **52.1%** | **47.5%** | **65.3%** | **73.8%** | **84.7%** | **87.2%** | **88.9%** | **79.5%** |
| Vehicle Driver | 33.2% | 30.5% | 40.2% | 45.1% | 52.6% | 56.3% | 57.0% | 50.0% |
| Vehicle Passenger | 18.9% | 16.9% | 25.1% | 28.7% | 32.1% | 30.9% | 31.9% | 29.5% |
| **Total Transit** | **15.2%** | **19.7%** | **11.5%** | **5.4%** | **2.1%** | **1.7%** | **1.2%** | **4.4%** |
| BART | 8.5% | 4.0% | 2.9% | 0.9% | 0.4% | 0.5% | 0.2% | 1.0% |
| Other Transit | 6.7% | 15.7% | 8.5% | 4.6% | 1.7% | 1.2% | 1.0% | 3.4% |
| **Bicycle** | **4.6%** | **2.9%** | **1.7%** | **1.3%** | **1.2%** | **1.3%** | **0.6%** | **1.4%** |
| **Walk** | **23.1%** | **28.1%** | **19.8%** | **15.7%** | **9.7%** | **8.4%** | **5.8%** | **12.3%** |
| **Other** | **5.0%** | **1.8%** | **1.8%** | **3.8%** | **2.2%** | **1.4%** | **3.5%** | **2.4%** |
| | | | | | | | | |
| *Total Trips* | | | | | | | | |
| **In-Vehicle Person** | **51.6%** | **47.6%** | **64.8%** | **75.1%** | **85.7%** | **87.5%** | **89.9%** | **80.0%** |
| Vehicle Driver | 34.9% | 31.9% | 43.9% | 51.4% | 59.3% | 61.7% | 63.2% | 55.5% |
| ***Vehicle Trip Factor*** | ***62.9%*** | ***57.4%*** | | | | | | |
| Vehicle Passenger | 16.7% | 15.7% | 20.9% | 23.6% | 26.4% | 25.8% | 26.7% | 24.5% |
| **Total Transit** | **19.4%** | **21.9%** | **14.7%** | **7.7%** | **3.3%** | **2.8%** | **1.7%** | **6.2%** |
| ***Transit Trip Factor*** | ***315.7%*** | ***355.6%*** | | | | | | |
| BART | 12.5% | 7.6% | 5.0% | 1.5% | 0.9% | 1.2% | 0.4% | 1.9% |
| Other Transit | 6.9% | 14.3% | 9.7% | 6.2% | 2.4% | 1.6% | 1.3% | 4.2% |
| **Bicycle** | **3.9%** | **3.7%** | **1.9%** | **1.3%** | **1.2%** | **1.4%** | **0.6%** | **1.5%** |
| **Walk** | **20.6%** | **25.0%** | **16.7%** | **12.7%** | **7.9%** | **7.1%** | **4.9%** | **10.3%** |
| **Other** | **4.4%** | **1.8%** | **1.9%** | **3.3%** | **1.8%** | **1.2%** | **2.9%** | **2.1%** |

***Note: Trip Factors = "within ¼ mile" & "¼ mile to ½ mile" mode share divided by Regional "Total" mode share***

**TABLE A-2: Mode Shares and Calculated Vehicle Trip Reduction and Transit Trip Increase Factors – Caltrain Commuter Rail**

***CIRCULAR BUFFER ANALYSIS***

| | Proximity of Resident's Home to **Caltrain Stations** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Within | 1/4 mile to | 1/2 mile to | Greater than 1 mile | | | | |
| Travel Characteristic | 1/4 mile | 1/2 mile | 1 mile | Urban | High-Sub | Low-Sub | Rural | Total |
| MODE SHARES | | | | | | | | |
| *Home-Based Work* | | | | | | | | |
| **In-Vehicle Person** | **80.8%** | **87.4%** | **81.0%** | **68.8%** | **87.9%** | **87.8%** | **94.9%** | **81.7%** |
| Vehicle Driver | 76.8% | 78.8% | 75.1% | 60.4% | 80.8% | 82.4% | 89.4% | 74.9% |
| Vehicle Passenger | 4.0% | 8.7% | 5.9% | 8.3% | 7.1% | 5.3% | 5.4% | 6.8% |
| **Total Transit** | **12.4%** | **7.8%** | **12.4%** | **20.6%** | **8.6%** | **7.9%** | **3.2%** | **12.2%** |
| Caltrain | 5.0% | 4.9% | 3.4% | 0.9% | 0.5% | 0.3% | 0.2% | 0.9% |
| Other Transit | 7.3% | 2.9% | 9.0% | 19.7% | 8.0% | 7.7% | 3.0% | 11.3% |
| **Bicycle** | **1.1%** | **1.9%** | **2.7%** | **2.3%** | **1.1%** | **1.7%** | **0.5%** | **1.8%** |
| **Walk** | **5.7%** | **2.7%** | **2.8%** | **6.5%** | **1.8%** | **2.0%** | **1.2%** | **3.4%** |
| **Other** | **0.0%** | **0.2%** | **1.0%** | **1.7%** | **0.7%** | **0.6%** | **0.2%** | **1.0%** |
| *Non-Work Trips* | | | | | | | | |
| **In-Vehicle Person** | **72.1%** | **81.0%** | **75.4%** | **66.8%** | **83.8%** | **86.3%** | **89.9%** | **79.5%** |
| Vehicle Driver | 50.6% | 54.6% | 48.0% | 40.5% | 51.9% | 55.6% | 57.8% | 50.0% |
| Vehicle Passenger | 21.5% | 26.4% | 27.4% | 26.4% | 31.8% | 30.7% | 32.1% | 29.5% |
| **Total Transit** | **4.3%** | **3.4%** | **5.9%** | **9.5%** | **2.5%** | **1.9%** | **1.2%** | **4.4%** |
| Caltrain | 1.6% | 1.4% | 0.5% | 0.1% | 0.1% | 0.1% | 0.0% | 0.1% |
| Other Transit | 2.7% | 2.0% | 5.4% | 9.4% | 2.4% | 1.8% | 1.1% | 4.3% |
| **Bicycle** | **2.6%** | **1.7%** | **1.3%** | **1.8%** | **1.1%** | **1.3%** | **0.6%** | **1.4%** |
| **Walk** | **16.8%** | **12.4%** | **13.9%** | **18.7%** | **10.3%** | **9.1%** | **5.2%** | **12.3%** |
| **Other** | **4.2%** | **1.6%** | **3.6%** | **3.2%** | **2.3%** | **1.4%** | **3.2%** | **2.4%** |
| *Total Trips* | | | | | | | | |
| **In-Vehicle Person** | **74.2%** | **82.7%** | **76.8%** | **67.3%** | **84.7%** | **86.6%** | **90.9%** | **80.0%** |
| Vehicle Driver | 56.9% | 60.9% | 54.6% | 45.2% | 58.5% | 61.0% | 64.0% | 55.5% |
| ***Vehicle Trip Factor*** | ***102.5%*** | ***109.6%*** | | | | | | |
| Vehicle Passenger | 17.3% | 21.8% | 22.2% | 22.1% | 26.3% | 25.6% | 26.9% | 24.5% |
| **Total Transit** | **6.2%** | **4.5%** | **7.5%** | **12.1%** | **3.9%** | **3.1%** | **1.6%** | **6.2%** |
| ***Transit Trip Factor*** | ***101.2%*** | ***73.5%*** | | | | | | |
| Caltrain | 2.4% | 2.3% | 1.2% | 0.3% | 0.2% | 0.1% | 0.1% | 0.3% |
| Other Transit | 3.8% | 2.2% | 6.3% | 11.9% | 3.7% | 3.0% | 1.5% | 5.9% |
| **Bicycle** | **2.2%** | **1.7%** | **1.6%** | **2.0%** | **1.1%** | **1.4%** | **0.6%** | **1.5%** |
| **Walk** | **14.1%** | **9.9%** | **11.2%** | **15.8%** | **8.4%** | **7.7%** | **4.4%** | **10.3%** |
| **Other** | **3.2%** | **1.2%** | **2.9%** | **2.8%** | **2.0%** | **1.2%** | **2.6%** | **2.1%** |

***Note: Trip Factors = "within ¼ mile" & "¼ mile to ½ mile" mode share divided by Regional "Total" mode share***

**TABLE A-3: Mode Shares and Calculated Vehicle Trip Reduction and Transit Trip Increase Factors – San Francisco MUNI Light Rail**

***CIRCULAR BUFFER ANALYSIS***

| | Proximity of Resident's Home to **MUNI Light Rail Lines** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Within | 1/4 mile to | 1/2 mile to | Greater than 1 mile | | | | |
| Travel Characteristic | 1/4 mile | 1/2 mile | 1 mile | Urban | High-Sub | Low-Sub | Rural | Total |
| MODE SHARES | | | | | | | | |
| *Home-Based Work* | | | | | | | | |
| **In-Vehicle Person** | **43.2%** | **41.6%** | **60.2%** | **79.7%** | **88.0%** | **87.8%** | **93.7%** | **81.7%** |
| Vehicle Driver | 36.4% | 36.5% | 54.3% | 70.6% | 81.2% | 82.4% | 88.3% | 74.9% |
| Vehicle Passenger | 6.8% | 5.2% | 5.9% | 9.1% | 6.8% | 5.4% | 5.3% | 6.8% |
| **Total Transit** | **32.5%** | **38.0%** | **31.9%** | **13.8%** | **8.2%** | **8.0%** | **4.4%** | **12.2%** |
| MUNI Light Rail | 8.2% | 2.7% | 2.3% | 0.2% | 0.1% | 0.1% | 0.0% | 0.7% |
| Other Transit | 24.3% | 35.4% | 29.6% | 13.6% | 8.1% | 7.9% | 4.4% | 11.5% |
| **Bicycle** | **5.7%** | **1.9%** | **1.8%** | **1.8%** | **1.3%** | **1.7%** | **0.5%** | **1.8%** |
| **Walk** | **15.6%** | **16.5%** | **5.9%** | **3.2%** | **1.8%** | **2.0%** | **1.2%** | **3.4%** |
| **Other** | **3.0%** | **1.9%** | **0.2%** | **1.5%** | **0.6%** | **0.5%** | **0.2%** | **1.0%** |
| *Non-Work Trips* | | | | | | | | |
| **In-Vehicle Person** | **52.1%** | **56.3%** | **61.3%** | **72.0%** | **83.9%** | **86.3%** | **89.0%** | **79.5%** |
| Vehicle Driver | 30.9% | 34.9% | 34.3% | 44.7% | 52.1% | 55.7% | 57.2% | 50.0% |
| Vehicle Passenger | 21.2% | 21.4% | 27.1% | 27.3% | 31.8% | 30.6% | 31.8% | 29.5% |
| **Total Transit** | **15.6%** | **17.3%** | **10.5%** | **7.1%** | **2.4%** | **2.0%** | **1.1%** | **4.4%** |
| MUNI Light Rail | 4.1% | 0.8% | 0.8% | 0.2% | 0.0% | 0.2% | 0.0% | 0.3% |
| Other Transit | 11.5% | 16.5% | 9.8% | 7.0% | 2.4% | 1.8% | 1.1% | 4.1% |
| **Bicycle** | **2.0%** | **2.0%** | **1.3%** | **1.7%** | **1.3%** | **1.3%** | **0.6%** | **1.4%** |
| **Walk** | **27.5%** | **23.4%** | **25.5%** | **15.4%** | **10.1%** | **9.1%** | **5.9%** | **12.3%** |
| **Other** | **2.8%** | **1.1%** | **1.3%** | **3.7%** | **2.3%** | **1.4%** | **3.4%** | **2.4%** |
| *Total Trips* | | | | | | | | |
| **In-Vehicle Person** | **49.8%** | **52.8%** | **61.1%** | **73.8%** | **84.9%** | **86.6%** | **89.9%** | **80.0%** |
| Vehicle Driver | 32.3% | 35.3% | 38.7% | 50.9% | 58.7% | 61.1% | 63.3% | 55.5% |
| ***Vehicle Trip Factor*** | ***58.2%*** | ***63.5%*** | | | | | | |
| Vehicle Passenger | 17.5% | 17.5% | 22.4% | 23.0% | 26.2% | 25.5% | 26.6% | 24.5% |
| **Total Transit** | **19.9%** | **22.2%** | **15.2%** | **8.7%** | **3.7%** | **3.2%** | **1.8%** | **6.2%** |
| ***Transit Trip Factor*** | ***322.9%*** | ***361.4%*** | | | | | | |
| MUNI Light Rail | 5.1% | 1.2% | 1.1% | 0.2% | 0.0% | 0.1% | 0.0% | 0.4% |
| Other Transit | 14.7% | 21.0% | 14.1% | 8.5% | 3.7% | 3.0% | 1.8% | 5.7% |
| **Bicycle** | **2.9%** | **2.0%** | **1.4%** | **1.7%** | **1.3%** | **1.3%** | **0.6%** | **1.5%** |
| **Walk** | **24.5%** | **21.7%** | **21.2%** | **12.5%** | **8.2%** | **7.7%** | **5.0%** | **10.3%** |
| **Other** | **2.9%** | **1.3%** | **1.1%** | **3.2%** | **2.0%** | **1.2%** | **2.8%** | **2.1%** |

***Note: Trip Factors = "within ¼ mile" & "¼ mile to ½ mile" mode share divided by Regional "Total" mode share***

**TABLE A-4: Mode Shares and Calculated Vehicle Trip Reduction and Transit Trip Increase Factors – Santa Clara VTA Light Rail**

***CIRCULAR BUFFER ANALYSIS***

| | Proximity of Resident's Home to **VTA Light Rail Stations** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Within | 1/4 mile to | 1/2 mile to | Greater than 1 mile | | | | |
| Travel Characteristic | 1/4 mile | 1/2 mile | 1 mile | Urban | High-Sub | Low-Sub | Rural | Total |
| MODE SHARES | | | | | | | | |
| *Home-Based Work* | | | | | | | | |
| **In-Vehicle Person** | **74.2%** | **90.8%** | **89.7%** | **69.6%** | **87.1%** | **87.5%** | **93.7%** | **81.7%** |
| Vehicle Driver | 70.6% | 81.5% | 83.2% | 61.2% | 80.1% | 82.2% | 88.3% | 74.9% |
| Vehicle Passenger | 3.6% | 9.3% | 6.5% | 8.3% | 7.0% | 5.2% | 5.4% | 6.8% |
| **Total Transit** | **24.0%** | **6.1%** | **4.3%** | **20.3%** | **8.8%** | **8.1%** | **4.5%** | **12.2%** |
| VTA Light Rail | 0.4% | 1.4% | 1.2% | 0.4% | 0.1% | 0.0% | 1.0% | 0.3% |
| Other Transit | 23.6% | 4.7% | 3.1% | 19.9% | 8.6% | 8.1% | 3.4% | 11.9% |
| **Bicycle** | **1.3%** | **0.7%** | **0.3%** | **2.4%** | **1.4%** | **1.8%** | **0.4%** | **1.8%** |
| **Walk** | **0.6%** | **2.2%** | **1.5%** | **6.4%** | **2.0%** | **2.0%** | **1.2%** | **3.4%** |
| **Other** | **0.0%** | **0.2%** | **4.2%** | **1.3%** | **0.7%** | **0.6%** | **0.2%** | **1.0%** |
| *Non-Work Trips* | | | | | | | | |
| **In-Vehicle Person** | **72.6%** | **84.7%** | **78.0%** | **67.1%** | **83.4%** | **86.3%** | **88.9%** | **79.5%** |
| Vehicle Driver | 45.3% | 49.4% | 46.4% | 41.4% | 51.8% | 55.7% | 57.2% | 50.0% |
| Vehicle Passenger | 27.3% | 35.4% | 31.6% | 25.8% | 31.6% | 30.5% | 31.8% | 29.5% |
| **Total Transit** | **11.3%** | **2.5%** | **1.9%** | **9.7%** | **2.5%** | **1.9%** | **1.1%** | **4.4%** |
| VTA Light Rail | 0.6% | 0.2% | 0.6% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% |
| Other Transit | 10.7% | 2.3% | 1.3% | 9.7% | 2.5% | 1.9% | 1.1% | 4.4% |
| **Bicycle** | **0.7%** | **0.5%** | **0.5%** | **1.8%** | **1.3%** | **1.3%** | **0.6%** | **1.4%** |
| **Walk** | **7.1%** | **9.0%** | **9.7%** | **19.0%** | **10.5%** | **9.2%** | **5.9%** | **12.3%** |
| **Other** | **8.3%** | **3.3%** | **9.9%** | **2.3%** | **2.4%** | **1.4%** | **3.5%** | **2.4%** |
| *Total Trips* | | | | | | | | |
| **In-Vehicle Person** | **73.0%** | **86.2%** | **80.8%** | **67.7%** | **84.2%** | **86.5%** | **89.9%** | **80.0%** |
| Vehicle Driver | 52.1% | 57.4% | 55.2% | 46.1% | 58.1% | 61.1% | 63.3% | 55.5% |
| ***Vehicle Trip Factor*** | ***93.9%*** | ***103.5%*** | | | | | | |
| Vehicle Passenger | 20.9% | 28.8% | 25.6% | 21.6% | 26.1% | 25.4% | 26.6% | 24.5% |
| **Total Transit** | **14.7%** | **3.4%** | **2.5%** | **12.2%** | **3.9%** | **3.1%** | **1.8%** | **6.2%** |
| ***Transit Trip Factor*** | ***239.7%*** | ***54.9%*** | | | | | | |
| VTA Light Rail | 0.6% | 0.5% | 0.7% | 0.1% | 0.1% | 0.0% | 0.2% | 0.1% |
| Other Transit | 14.2% | 2.9% | 1.8% | 12.1% | 3.8% | 3.1% | 1.6% | 6.0% |
| **Bicycle** | **0.9%** | **0.5%** | **0.5%** | **2.0%** | **1.3%** | **1.4%** | **0.6%** | **1.5%** |
| **Walk** | **5.3%** | **7.3%** | **7.8%** | **16.0%** | **8.6%** | **7.7%** | **5.0%** | **10.3%** |
| **Other** | **6.1%** | **2.5%** | **8.5%** | **2.1%** | **2.0%** | **1.2%** | **2.8%** | **2.1%** |

***Note: Trip Factors = "within ¼ mile" & "¼ mile to ½ mile" mode share divided by Regional "Total" mode share***

# APPENDIX B: SUMMARIES OF ELASTICITY DATA FROM SELECTED STUDIES REVIEWED FOR THIS RESOURCE PAPER (*Thanks To Reid Ewing, who compiled the majority of the studies' data*)

**Table B-1. Multivariate Statistical Studies Using Aggregate Data**

| | Study Design | Subjects | Geography | Sample (N) | Source of Elasticities | Model Form | Outcome Variables | Built Environmental Variables | Control Variables | Elasticities | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Messenger and Ewing (1996) | cross sectional | bus stops | ¼ mile buffers | | computed from model coefficients | linear equations estimated jointly | | | | | |
| Bhatia (2004) | cross sectional | general population | communities of varying size | 20 DC area communities | derived from author's dataset | linear regression for walk share<br>loglinear regression of transit share | % walk trips<br>% transit trips | household density | average household size<br>median household income | <u>walk share of all trips</u><br>household density: 1.100<br>(median household income: 0.1973)<br><u>transit share of all trips</u><br>household density: 0.7889<br>(median household income: -0.4055) | |
| Braza et al., (2004) | cross sectional | elementary school students | | 34 schools in California (with their aggregate mode shares) | derived from authors' dataset | linear regression | % walk or bike to school | population density within ½ mile of school<br>intersections per street mile within ½ mile of school | school size<br>% students receiving public assistance<br>% students of various ethnicities minimum distance for busing | <u>walk share of school trips</u><br>population density: 0.2963<br>intersections per street mile: 0.5776<br>(% receiving public assistance: 0.1788) | |

**Table B-2. Multivariate Statistical Studies Using Disaggregate Data**

| | Study Design | Subjects | Geography | Sample (N) | Source of Elasticities | Model Form | Outcome Variables | Built Environmental Variables | Control Variables | Elasticities | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ewing et al. (1996) | cross sectional | | | | | | | accessibility index<br>walking quality factor<br>proportion four-way intersections<br>proportion quadrilateral blocks<br>average sidewalk<br>proportion of area within ¼ mile of<br>proportion commercial parcels with front or side parking | annual income per person<br>number of children under 5<br>gender<br>driver's license<br>employed status<br>trip distance<br>transit service intensity | proportion within ¼ mile of store: 0.365<br>walking quality factor: 0.119<br>walking/biking/transit choice for non-work<br>intensity factor: 0.084<br>walking quality factor: 0.183<br>sidewalk width: 0.087<br>front and side parking: -0.121 | other variables have insignificant coefficients |
| Kitamura et al. (1997) | cross sectional (with neighborhoods matched on income and disparate in land use characteristics) | general population | large neighborhoods and varying distances around residences | 3,795-10,767 individuals in San Francisco Bay Area | computed from model coefficients | linear regression | fraction of walk/bike trips<br>fraction of transit trips | high density<br>presence of backyard<br>distance to nearest grocery store<br>distance to nearest<br>distance to nearest bus stop<br>sidewalks in neighborhood | household size<br>number of driver's license<br>high school<br>graduate degree<br>professional occupation<br>high personal income<br>medium personal income<br>attitudes on a variety of subjects | share of walk/bike<br>distance to nearest bus stop: -1.034<br>distance to nearest park: -1.07<br>(household size: -<br>share of transit trips<br>distance to nearest rail station: -1.619<br>distance to nearest park: -1.450<br>(number of vehicles: -8.794) | |
| Kockelman (1997) | cross sectional | adults | TAZs and census tracts | 52,650 trips in the San Francisco Bay Area | reported by author | binomial logit | probability of walking or biking | job accessibility (gravity formulation)<br>population density<br>job density<br>land use mix (dissimilarity index)<br>land use balance (entropy formulation)<br>non-work land use balance (entropy formulation) | household size<br>auto ownership<br>income per<br>gender<br>age<br>driver's license<br>employment<br>race<br>professional occupation | walk/bike choice<br>accessibility: 0.22<br>non-work land use balance: 0.23<br>(vehicles per person: -0.60)<br>(household size: 0.48) | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| Greenwald and Boarnet (2001) | cross sectional | general population | | 1,084 individuals in Portland, OR | computed from model coefficients | ordered probit | number of nonwork walk trips per person | population density of census block group<br>retail employment density w/i 1-mile of<br>% quadrilateral street sections<br>pedestrian environment factor<br>population density of zip code<br>retail job density w/i zip code | age<br>number of vehicles per<br>gender<br>household number of<br>number of employed<br>ethnicity<br>workday median trip distance<br>median trip speed | | mean values of dependent and independent variables supplied by used census block group and 1-mile buffer variables rather than zip code level variables as the smaller geography is more |
| Cervero (2002) | cross sectional | general population | | 1,960 trips for all purposes in Montgomery County, MD | reported by author | multinomial logit | probability of taking transit | gross density<br>land-use diversity<br>ratio of sidewalk to road miles<br>proportion of multi-family households within ½ mile of metrorail station | vehicle<br>gender<br>driver's license<br>full-time employment | transit choice all trip purposes<br>gross density origin: 0.511<br>gross density destination: 0.268<br>land-use diversity origin: 0.615<br>land-use diversity destination: 0.452<br>sidewalk ratio destination: 0.327<br>proportion multifamily with ¼ mile of station origin: 0.195 | add Cervero's explanation |
| Reilly (2002) | cross sectional | general population | buffer widths around residences of ¼ to 4 miles | 7,604 trips for non-work purposes in San Francisco, CA | computed from model coefficients | multinomial logit | probability of walking<br>probability of taking transit | population density<br>distance to closest commercial use<br>proportion commercial uses<br>dissimilarity index<br>mean block size<br>intersection density<br>proportion detached homes<br>median year built<br>mean parcel size | age<br>driver's license<br>employment<br>race/ethnicity<br>household size<br>household vehicles/driver<br>home ownership<br>weekend trip<br>transit access index | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| Cervero and Duncan (2003) | cross sectional | general population | | 7,836 trips for selected purposes in San Francisco, CA | computed from model coefficients | multnomial logit | probability of walking on a trip of less than 5 miles<br>probability of biking on a trip of less than 5 miles | employment density<br>land-use diversity factor<br>pedestrian-friendly design factor | gender<br>race<br>disability<br>number of household vehicles<br>number of household bicycles<br>trip purpose<br>trip distance<br>weekend trip<br>nighttime trip<br>rainfall<br>slope<br>low-income neighborhood | <u>walk choice</u><br>employment density at origin: 0.0411<br>land-use diversity at origin<br>land-use diversity at destination<br>pedestrian-friendly design at origin<br>pedestrian-friendly design at destination<br>(trip distance: -3.334)<br>(number of vehicles: -1.241) | |
| Rajamani et al. (2003) | cross sectional | general population | | 2,500 home-based nonwork trips in Portland, OR | reported by authors | multinomial logit | probability of walking on nonwork trip<br>probability of taking transit on nonwork trip | population density<br>land use mix diversity index<br>% cul-de-sacs in neighborhood<br>street connectivity index<br>accessibility indices (only for recreation trips) | age<br>gender<br>handicap<br>race<br>household income<br>vehicles per adult<br>number of children<br>number of adults<br>travel times and costs | <u>walk choice for nonwork trips</u><br>population density: 0.0096<br>land use mix diversity index: 0.3610<br>% cul-de-sacs: -0.0046<br>(walk travel time: -0.8655)<br>(vehicles per adult: -1.0464)<br>(number of children: -0.1687)<br><u>transit choice for nonwork trips</u><br>population density: 0.0775<br>land use mix: -0.0370<br>% cul-de-sacs: 0.0004<br>(transit travel time: -0.8689)<br>(vehicles per adult: 0.0444)<br>(number of children: -0.2104) | check with Gerritt both on calculation of elasticities and definitions of BE variables<br>what happened to other variables<br>they say higher densities improve the chances of walking but elasticity is small<br>probabilities aggregated to obtain elasticities of mode shares<br>didn't include bike elasticities due to small sample of bike trips |
| Ewing et al. (2004) | cross sectional | students | TAZs | 711 trips to school in Gainesville, FL | reported by author | multinomial logit | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| Zhang (2004) | cross sectional | general population | | 1,619 home-based work trips and 1,036 home-based nonwork trips in Boston (separate sample of trips for Hong Kong) | reported by author | multinomial logit | probability of walk or bike trip<br>probability of transit trip | population density (origin and destination)<br>job density (origin and destination)<br>land use balance (origin and destination – entropy formulation)<br>% cul-de-sac intersections (origin and destination) | age less than 30<br>full-time worker status<br>home ownership<br>female no children<br>vehicles per worker<br>distance to nearest transit station<br>travel cost and time by different modes | <u>walk/bike choice for work</u><br>population density: 0.105<br>job density: 0.026<br>land use balance: -0.017<br>% cul-de-sacs: -0.072<br>(walk time: -0.5534)<br>(vehicles per worker: -0.2483)<br><u>walk/bike choice for</u><br>population density: 0.060<br>job density: -0.004<br>land use balance: 0.118<br>% cul-de-sacs: -0.047<br>(walk time: -0.8285)<br>(vehicles per worker: -0.2817)<br><u>transit choice for work trips</u><br>population density: 0.118<br>job density: 0.090<br>land use balance: -0.020<br>% cul-de-sacs: -0.083<br>(transit time: -0.2794)<br>(vehicles per worker: -0.3688)<br><u>transit choice for nonwork trips</u><br>population density: 0.126<br>job density: 0.004<br>land use balance: 0.121<br>% cul-de-sacs: -0.044<br>(transit time: -0.2367)<br>(vehicles per worker: -0.2828) | elasticities reported are probability weighted average individual elasticities for each mode relative to built environmental variables averaged for origin and destination<br>these elasticities may not relate to mode share but instead to probabilities – ask author |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hedel and Vance (2006) | German Mobility Panel: eight overlapping waves (1996-2003) each comprising a group of households surveyed for one week in three successive years | Each licensed driver of each household (4300 individuals in 2600 households) | Germany | 4300 individuals in 2600 households | Reported by authors | 2-part model: probit and OLS estimators.<br><br>3-tiers: individual, household, zip code (insufficient data for hierarchical modeling)<br><br>Instrumented neighborhood variables (IV):<br><br>% bldgs <1945<br>% bldgs 1945-85 | Vehicle trips<br>VMT | Commercial diversity: entropy mix of 3 types of commercial<br>Commercial density: commercial businesses per acre in zip code.<br>Street density: sq feet per acre in zip code<br>Access to transit: walk minutes to bus stop | Disposable per capita income, age, gender, education, employment status, home/work distance, auto ownership | VT elasticities:<br>Commerc density = -0.031<br>Comm diversity* = +0.132<br>Transit walk dist = +0.022<br><br>VMT elasticities:<br>Commerc density = -1.556<br>Comm diversity* = +2.646<br>Transit walk dist = +1.151<br>Street density* = -0.092<br><br>** Not significant at the 5% level*<br><br>VT elasticities:<br>Commerc density = -0.051<br>Comm diversity* = -0.336<br>Transit walk dist = +0.032<br><br>VMT elasticities:<br>Commerc density = -4.349<br>Comm diversity* = -34.53<br>Transit walk dist = +2.567<br>Street density = -0.394<br><br>** Not significant at the 5% level* | |
| Guo, Bhat, Copperman | SF Bay Area Travel Survey, 2000 | Statistical sample of Bay Area households | Sample of households in 9 urban area counties | 19,400 individuals | Probit model "parameters" reported. | Bivariate ordered probit model | Home-based auto trip generation (excludes NHB) for: 1) maintenance and 2) discretionary | Mix of resid, comer, other land use;<br>Pop density, bike network density, street density and grain, transit availability, maintenance businesses density, discretionary business density, TAZ accessibility to shopping, rec, employment | Household size, income, structure, autos, individual age, gender, ethnicity | "Parameters" for Maintenance trips:<br>Pop density = -2.664<br><br>"Parameters" for Discretionary trips:<br>¼ mi diversity: -0.188<br>Fraction residential = +0.32<br><br>Pop density = -1.531<br>Highway density = -0.046 | Does not address self-selection |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cao, Mokhtarian, Handy | Mail-out survey to with response by 320 movers and 230 non-movers | Households who moved within region in 4 traditional and 4 suburban neighborhoods. | Eight No. Cal.<br><br>neighborhoods in Mt View area, Sacramento, Santa Rosa, Modesto | 547 households, of which about 320 had moved within year prior to survey | | Maximum Likelihood Est, Structural Equations Model | Changes in auto ownership, driving | Accessibility to mall, downtown, amenities.<br><br>Outdoor spaciousness yard size, off-street parking<br><br>Socializing: diverse neighbors, outdoor presence | Residential preference, travel attitudes | SEM Total Effects:<br><br>Spaciousness = +0.014<br><br>Accessibility = -0.223<br><br>Socializing = -0.132<br>Leisure businesses = -0.011 | |

**Table B-3. Quasi-Experimental Studies Using Disaggregate Data**

| | Study Design | Subjects | Geography | Sample (N) | Source of Elasticities/ Effect Sizes | Model Form | Outcome Variables | Built Environmental Variables | Control Variables | Marginal Effects | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ewing et al. (1994) | | | | | derived from authors' dataset | | | | | | |
| Cervero and Radisch (1996) | quasi-experimental with neighborhoods matched on regional location, transit and freeway access, and household | general population | 2 neighborhoods in East Bay of San Francisco-Oakland | 820 work trips<br><br>(620 residents for nonwork travel survey)<br>(840 residents for work travel survey) | computed from model coefficients | binomial logit | probability of walking to work | traditional neighborhood design (Rockridge dummy variable) | household size<br><br>household income | with traditional design<br><br>% greater probability of walking to nonwork destinations | assumed a mean of two vehicles per household |
| Hess et al. (1999) | quasi-experimental with neighborhoods matched on population density and median | neighborhood commercial centers | 12 neighborhoods in Seattle, WA | 12 commercial centers | derived from authors' dataset | linear regression | pedestrians/1000 residents | urban neighborhood design (dummy for urban neighborhoods with small blocks, sidewalks, and direct routes) | population density<br><br>median household income<br>number of businesses | with urban neighborhood design<br><br>146% more walk trips to commercial centers | sidewalk completeness and block size are highly correlated |
| Handy and Clifton (2001) | quasi-experimental with neighborhoods matched on income (statistical controls for individual SES differences) | general population | 6 neighborhoods in Austin, TX (2 traditional, 2 early-modern, 2 late-modern) | 1,377 residents | computed from model coefficients | linear regression | number of walk trips for shopping | traditional neighborhood design (Old West Austin neighborhood dummy) | age<br>children in household<br>gender<br>income<br>miles to store<br>quality of stores index<br>walking incentive index<br>walking comfort index<br>strolling frequency | with traditional design<br>120% more walk trips for shopping | marginal effect size computed at mean values of all independent variables |
| Lund (2003) | quasi-experimental with neighborhoods matched on *** (statistical controls for individual SES differences) | residents of single-family homes | 8 neighborhoods in Portland, OR (4 urban, 4 suburban) | 427 residents | computed from model coefficients | linear regression | number of walk trips to destinations<br><br>number of strolling trips | on-site retail<br>on-site retail and park<br><br>inner-city location | age<br>gender<br><br>race<br>children of varying ages<br>homemaker status<br><br>length of residence<br>attitudes on a variety of subjects | with on-site retail<br>14% more walk trips to destinations<br>18% fewer strolling trips<br>with on-site retail and park<br><br>33% more walk trips to destinations<br>9% fewer strolling trips<br>at inner-city locations<br><br>6% more walk trips to destinations<br>2% fewer strolling trips | marginal effect sizes |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Khattak and Rodriguez (2004) | quasi-experimental with neighborhoods matched on house value, age of development, transit service availability, and regional | residents of single-family homes | 2 suburban neighborhoods in Chapel Hill, NC | 711 residents | computed from model coefficients | negative binomial regression | number of walk and bike trips | neo-traditional neighborhood design (Southern Village dummy) | gender<br>age<br>number of vehicles<br>household size<br>housing type (single family) | with neo-traditional design<br>88% more walk and bike trips overall<br>22% more recreational walk and bike trips<br>189% more utilitarian walk and bike trips | |
| Rose and Dill (2004) | quasi-experimental with neighborhoods matched on house size, house value, age of development, and regional location (statistical | residents of single-family homes | 3 suburban neighborhoods in Portland, OR | 210 residents | computed from model coefficients | poisson regression | number of walk trips<br>number of walk trips for shopping<br>number of walk trips for recreation | neo-traditional neighborhood design (Fairview Village dummy) | age<br>number of vehicles<br>gender<br>number of children | % more walk trips<br>% more walk trips for shopping<br>% more walk trips for recreation | marginal effect size computed at mean values of all independent variables<br>base is average for two conventional neighborhoods |
| Mohammadian, A; Zhang | US National Household Travel Survey, 2001; market-segment cluster analysis | Statistical sample of US households | Sample of households in 50 US states | 640,000 trips, 160,000 people, 70,000 households | (none available, just cluster differences) | Cluster analysis, categories incl: Young achievers | Trips by purpose, VMT, % transit, non-motorized trips, tours | Census tract: Housing density, employt density, pop density, intersection density, road density, block size, | Household age group, education, occupation<br>Other component analysis factors: vehicles, income, ethnicity,. | (None available) | Sample cluster results for:<br>2,3. Young suburbans |
| Dill | Home-delivered survey with response by 312 households | | 8 developments near MAX stations in the Portland, OR area | 312 households, 247 suburban, between 13 and 68 households in each study development | | | Percen t Commuting by Transit | Estimated walk trip time from transit station to work/school | | >30% transit share for walk trip times <15 minutes<br>20-25% transit share for walk trip times 15-30 minutes<br><5% transit share for walk trip times > 30 minutes | |
| Zhou, Gould, O'Flaherty | South Coast Air Quality Management District Survey | UCLA Faculty and Staff | Greater Los Angeles area | 2,484 employees | | | Transit share | Within 1/4 Mile of Bus Stop<br>Transit Carrier | | 7-12% higher transit mode share, depending on carrier | |
| MTC Planning Section | SF Bay Area Travel Survey, 2000 | Statistical sample of Bay Area households | San Francisco Bay Area | 35,000 residents in 15,000 households | | | Transit share<br>Auto Ownership<br>VMT | Distance from train/ferry station for residence and work | | Those living and working within 1/2 mile of transit make 42% of commutes<br>About 1/3 of households within 1/2 mile radius of transit/ferry station have no auto<br>Households within 1/2 mile of transit/ferry station generate half the VMT of suburban and rural residents | |

## APPENDIX C: EXPERT RESEARCH PANEL PARTICIPANTS

- **MPO Participants**
  - Mark Butala, Compass Blueprint Program Manager
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  - Jerry Walters, P.E., Principal
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  - Richard W. Willson, Ph.D., AICP
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    Dept. of City & Regional Planning
    Cal Poly Pomona

- **Reviewer, Invited and Unable to Attend**
  - James Corless, Senior Planner
    Metropolitan Transportation Commission (MTC)

- **Proposition 1C TOD Program Staff Attending**
    - Linda Wheaton, Assistant Deputy
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      Department of Housing and Community Development
    - Russ Schmunk, Assistant Deputy
      Division of Financial Assistance
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    - Craig Morrow, TOD Program Manager
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# BIBLIOGRAPHY

## BIBLIOGRAPHY OF DOCUMENTS REVIEWED

Anderson, Michael David and Sharfi, Khalid and Gholston, Sampson. *Direct Demand Forecasting Model for Small Urban Communities Using Multiple Linear Regression*. Transportation Research Board, 2006.

de Abreu e Silva, João and Golob, Thomas F and Goulias, Konstadinos G. Effects of Land Use Characteristics on Residence and Employment Location and Travel Behavior of Urban Adult Workers. Transportation Research Board, TRR 1977, 2006.

Bagley, M. & Mokhtarian, P. (2002). The Impact of Residential Neighborhood Type on Travel Behavior: A Structural Equations Modeling Approach. *Annals of Regional Science*, *36*, 279-297.

Barnes, G. (2001). *Population and Employment Density and Travel Behavior in Large U.S. Cities*. Minneapolis: Minnesota Department of Transportation.

Bento, A., Cropper, M., Mobarak, A., & Vinha, K. (2005, August). The Effects of Urban Spatial Structure on Travel Demand in the United States. *The Review of Economics and Statistics 87*, 466-478.

Bertaud, A. (2003). Clearing the Air in Atlanta: transit and smart growth or conventional economics? *Journal of Urban Economics*, *54*, 379-400.

Besser, L. M & Dannenberg, A. L. (2005). Walking to public transit: steps to help meet physical activity recommendations. *American Journal of Preventive Medicine*, *29*, 273-280.

Bhat, C. R and Guo, J. Y. (2006). *Comprehensive Analysis of Built Environment Characteristics on Household Residential Choice and Automobile Ownership Levels*. Washington, DC: Transportation Research Board.

Boarnet, M and Crane, R. (2001, November). The Influence of Land Use on Travel Behavior: Specification and Estimation Strategies. *Transportation Research Part A: Policy and* Practice, *35*(9), 823-845.

Boarnet, M & Crane, R. (2001). *Travel by Design: The Influence of Urban Form on Travel*. New York: Oxford University Press.

Boarnet, M.G & Sarmiento, S. (1998). Can Land-use Policy Really Affect Travel Behaviour? A Study of the Link between Non-work Travel and Land-use Characteristics. *Urban Studies*, *35*(7), 1155-1169.

Braza, M., Shoemaker, W., & Seeley, A. (2004). Neighborhood design and rates of walking and biking to elementary school in 34 California communities. *American Journal of Health Promotion*, *19*, 128-136.

Cao, X., Mokhtarian, P. L., & Handy, S. L. (2006). Neighborhood Design and Vehicle Type Choice: Evidence from Northern California. *Transportation Research Part D, 11,* 133–145.

Cao, X., Mokhtarian, P. L., & Handy, S. L. (2006). *Impacts of the Built Environment and Residential Self-Selection on Nonwork Travel: Seemingly Unrelated Regression Approach*. Washington, DC: Transportation Research Board.

Cao, X., Handy, S. L., & Mokhtarian, P. L. (2006). The influences of built environment and residential self-selection on pedestrian behavior: evidence from Austin, TX. *Transportation, 33*, 1-20.

Cao, Xinyu, Mokhtarian, Patricai L., and Handy, Susan L. (2007) *Do Changes in Neighborhood Characteristics Lead to Changes in Travel Behavior?* Paper Presentation at the 11th World Conference on Transportation Research, June 24-28, 2007. University of California, Berkeley.

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

Cervero, R. (1993). Evidence on Travel Behavior in Transit-Supportive Residential Neighborhoods. *Transit-Supportive Development in the United States: Experiences and Prospects*. Washington, D.C.: Technology Sharing Program, U.S. Department of Transportation, 127-163.

Cervero, R. (1993). Ridership Impacts of Transit-Focused Development in California. Berkeley: Report to the California Department of Transportation, IURD Monograph.

Cervero, R. (1993). Transit-Supportive Development in the United States: Experience and Prospects, Federal Transit Administration.

Cervero, R. (1994). Rail Transit and Joint Development. Journal of the American Planning Association 60(1), 83-94.

Cervero, R. (1994). Rail-Oriented Office Development in California: How Successful? *Transportation Quarterly*, *48*, 33-44.

Cervero, R. (1994). Transit-based Housing in California: Evidence on Ridership Impacts. *Transportation Policy*, *1*(3), 174-183.

Cervero, R. (1995). Rail Access Modes and Catchment Areas for the BART System. BART @ 20 Study, IURD, Monograph 50.

Cervero, R. (1996). Mixed Land-Uses and Commuting: Evidence from the American Housing Survey. *Transportation Research A*, 30, 361-377.

Cervero, R. (2001). Walk-and-Ride: Factors Influencing Pedestrian Access to Transit, *Journal of Public Transportation*, 3(4), 1-23.

Cervero, R. (2002, June), Built Environments and Mode Choice: Toward a Normative Framework. *Transportation Research Part D: Transport and Environment, 7*(4), 265-284.

Cervero, R. (2006). Alternative Approaches to Modeling the Travel-Demand Impacts of Smart Growth. *Journal of the American Planning Association, 72*(3), 285-295.

Cervero, R. (2006). Office Development, Rail Transit, and Commuting Choices, *Journal of Public Transportation*, 9(5), 41-55.

Cervero, R & Duncan, M. (2006). Which Reduces Vehicle Travel More: Jobs-Housing Balance or Retail-Housing Mixing? *Journal of the American Planning Association*, *72*(4), 475-490.

Cervero, R. (2007). Transit Oriented Development's Ridership Bonus: A Product of Self Selection and Public Policies, *Environment and Planning A*, (forthcoming).

Cervero, R. & Duncan, M. (2002). Residential Self Selection and Rail Commuting: A Nested Logit Analysis. Berkeley: UCTC Working Paper; http://www.uctc.net/papers/604.pdf

Cervero, R. & Duncan, M. (2003). Walking, Bicycling, & Urban Landscapes: Evidence from the San Francisco Bay Area. *American Journal of Public Health, 93,* 1478-1483.

Cervero, R. and Duncan, M. (2006). Which Reduces Vehicle Travel More: Jobs-Housing Balance or Retail-Housing Mixing? *Journal of the American Planning Association*, 72(4), 475-490.

Cervero, R and Ewing, R. (2002). Travel and the Built Environment-Synthesis, University of California at Berkeley Institute of Urban and Regional Development.

Cervero, R & Gorham, R. (1995). Commuting in Transit Versus Automobile Neighborhoods. *Journal of the American Planning Association*, *61(1)*, 210-225.

Cervero, R & Kockelman, K. (1997). Travel Demand and the 3Ds: Density, Diversity, & Design. *Transportation Research D*, *2*, 199-219.

Cervero, R., Landis, J., and Hall, P. (1992). Transit Joint Development in the United States: A Review of Recent Experiences and an Assessment of Future Potential. Washington: Urban Mass Transportation Administration, U.S. Department of Transportation; Monograph 42, Institute of Urban and Regional Development.

Cervero, R & Radisch, C. (1996). Travel Choices in Pedestrian Versus Automobile Oriented Neighborhoods. *Transport Policy*, *3*, pp. 127-141.

Cervero, R & Seskin, S. (1995). *An Evaluation of the Relationships Between Transit and Urban Form*. Washington, D.C: Transit Cooperative Research Program, Transportation Research Board.

Cervero, R., et. al. (2004). *Transit Oriented Development in the United States: Experiences, Challenges, Prospects*. TCRP Report 102.

Chapleau, R and Morency, C and Madituc, G. *Impacts off Settlement Patterns and Dynamics On Urban Mobility Behaviour: Findings From The Analysis Of Multiple Data Sources*. Elsevier, 2001.

Chatman, D. G. (2003). How Density and Mixed Uses at the Workplace Affect Personal Commercial Travel and Commute Mode Choice. *Transportation Research Board*, TRR 1831.

Clifton, K. J. & Dill, J. (2005). *Women's Travel Behavior and Land Use: Will New Styles of Neighborhoods Lead to More Women Walking?* Washington, DC: Transportation Research Board.

Coevering, V. & Schwanen, T. (2006). Re-evaluating the impact of urban form on travel patterns in Europe and North-America. *Transport Policy 3*, 229-239.

Crane, R. (1996) On form versus function: Will the New Urbanism reduce traffic or increase it? *Journal of Planning Education and Research, 15*(3), 117-126.

Crane, R. (1996). Cars and Drivers in the New Suburbs: Linking Access to Travel in Neotraditional Planning. *Journal of the American Planning Association*, *62*, 51-65.

Crane, R. (2000). The Influence of Urban Form on Travel: An Interpretive Review. *Journal of Planning Literature*, *15*(1), 3-23.

Crane, R. & Crepeau, R. (1998). Does Neighborhood Design Influence Travel? A Behavioral Analysis of Travel Dairy and GIS Data. *Transportation Research D*, *3*(4), 225-238.

Criterion Planners/Engineers and Fehr & Peers Associates. (2001). "Index 4D Method: A Quick Response Method of Estimating Travel Impacts of Land Use Changes", United States Environmental Protection Agency Technical Memorandum.

de Abreu e Silva, J. & Golob, T. F and Goulias, K. G. (2006). *Effects of Land Use Characteristics on Residence and Employment Location and Travel Behavior of Urban Adult Workers*. Transportation Research Board, TRR 1977.

Dieleman, F., Dijst, M., & Burghouwt, G. (2002). Urban form and travel behavior: Micro-level household attributes and residential context. *Urban Studies*, 39(3), 507-537.

Dill, Jennifer. (2003). "Transit Use and Proximity to Rail: Results from Large Employment Sites in the San Francisco Bay Area", Transportation Research Board Annual Meeting CD-ROM.

Dill, J. (2006). *Travel and Transit Use at Portland Area Transit-Oriented Developments (TODs)*. TransNow, Department of Civil Engineering, University of Washington, Seattle WA.

Dill, J., & Wilson, E. Factors affecting work site mode choice: Findings from Portland, OR. *86th Annual Meeting of the Transportation Research Board*, Washington, D.C.

DKS Associates, University of California, Irvine, University of California, Santa Barbara and Utah State University. (2007). Assessment of Local Models and Tools for Analyzing Smart-Growth Strategies: Final Report. Prepared for the State of California Business, Transportation and Housing Agency, and California Department of Transportation.

Doyle, S., Kelly-Schwartz, A., Schlossberg, M., & Stockard, J. (2006). Active community environments and health: The relationship of walkable and safe communities to individual health. *Journal of the American Planning Association*, *72*, 19-31.

Dunphy, R. and Fisher, K. (1993). Transportation, Congestion, and Density: New Insights, Urban Land Institute.

Eliasson, John and Mattsson, L-G. *A MODEL FOR INTEGRATED ANALYSIS OF HOUSEHOLD LOCATION AND TRAVEL CHOICES*. Transportation Research A 34, 375-394, Elsevier, 2000.

Environmental Protection Agency. (2001). *Our Built and Natural Environments: Technical Review of the Interactions between Land Use, Transportation, & Environmental Quality*. http://www.epa.gov/smartgrowth/built.htm

Evans, J., Stryker, A., Pratt, R., & Kuzmyak, R. (forthcoming in 2007). Transit Oriented Development. *Traveler Response to System Changes, Chapter 17*. TCRP Report 95.

Ewing, R. (1995). Beyond Density, Mode Choice, & Single-Purpose Trips. *Transportation Quarterly*, *49*, 15-24.

Ewing, R. (1996). *Pedestrian- and Transit-Friendly Design*. Tallahassee: Florida Department of Transportation, Appendix C.

Ewing, R. and Cervero, R. (1998). *Travel and the Built Environment*.

Ewing, R & R. Cervero. (2001). Travel and the Built Environment: A Synthesis. *Transportation Research Record, 1780*, 87-114.

Ewing, R., DeAnna, M., & Li, S. (1996). Land Use Impacts on Trip Generation Rates. *Transportation Research Record, 1518*, 1-7.

Ewing, R., Dumbaugh, E., & Brown, M. (2001). *Internalizing Travel by Mixing Land Uses: Study of Master-Planned Communities in South Florida*. Washington, DC: Transportation Research Board.

Ewing, R., Haliyur, P., & Page, G.W. (1994) Getting Around a Traditional City, a Suburban PUD, & Everything In-Between. *Transportation Research Record, 1466*, 53-62.

Ewing, R., Pendall, R., & Chen, D. (2003). *Measuring Sprawl and Its Transportation Impacts*. Washington, DC: Transportation Research Board.

Ewing, R., Pendall, R., Chen, D. (2003). *Measuring Sprawl and Its Impact*. Washington, DC: Smart Growth America.

Ewing, R., Handy, S. L., Brownson, R., & Clemente, O. (2006). *Identifying and Measuring Urban Design Qualities Related to Walkability*. Washington, DC: Transportation Research Board.

Fehr & Peers Associates. Recovered from: http://www.fehrandpeers.com/fp-lib/public/forecast-td-dirRidershp-approach.pdf

Fehr & Peers Associates. (2002). *Travel Forecasting Approach for Smart Growth Twin Cities*.

Fehr & Peers Associates. (2003). *4D Application to SACMET Travel Demand Model*.

Fontaine, M D. *Factors Affecting Traveler Mode Choice: A Synthesis of the Literature*. Virginia Transportation Research Council; Virginia Department of Transportation, 2003.

Frank, L., Chapman, J., & Bradley, M., & Lawton, T. K. (2005). *Travel Behavior, Emissions & Land Use Correlation Analysis in the Central Puget Sound*. Washington State Department of Transportation.

Frank, L.D & Pivo, G. (1994). Impacts of Mixed Use and Density on Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, & Walking. *Transportation Research Record 1466*, 44-52.

Fulton, J. E., Shisler, J. L., Yore, M. M., & Caspersen, C. J. (2005). Active transportation to school: Findings from a national survey. *Research Quarterly for Exercise and Sport*, *76*, 352-357.

Fulton, W., Pendall, R., Nguyen, M., Harrison, A. (2001). *Who Sprawls Most? How Growth Patterns Differ Across the U.S.* Washington, DC: The Brookings Institution Center on Urban and Metropolitan Policy, 24.

Furth, Peter G., Mekuria, Maaza C., and SanClemente, Joseph L. Parcel-Level Modeling to Analyze Transit Stop Location Changes. *Journal of Public Transportation*. Vol. 10, No 1, 2007. p 73

Geurs, K. & van Wee, B. (2006). Ex-post Evaluation of Thirty Years of Compact Urban Development in the Netherlands. *Urban Studies*, *43*(1), 139-160.

Gorham, R. *Comparative Neighborhood Travel Analysis: An Approach to Understanding the Relationship between Planning and Travel Behavior. In: In Perpetual Motion: Travel Behavior Research Opportunities and Application Challenges...* Elsevier, 2002.

Giuliano, G., Hu, H., & Lee, K. (2003). *Travel Patterns of the Elderly: The Role of Land Use*. Los Angeles, CA: METRANS Transportation Center.

Giuliano, Genevieve and Hu, His-Hwa and Lee, Kyoung. *Travel Patterns of the Elderly: The Role of Land Use*. METRANS Transportation Center; University of Southern California. School of Policy, Planning, and Development; California Department of Transportation; Dept. of Transportation Research and Special Programs Administration, 2003.

Greenwald, Michael. *Relationship Between Land Use and Trip Internalization Behaviors: Evidence and Implications*. Transportation Research Board, 2006.

Greenwald, M. J. (2003). The Road Less Traveled: New Urbanist Inducements to Travel Mode Substitution for Nonwork Trips. *Journal of Planning Education and Research*, 23, (39-57).

Greenwald, M. J. (2006). *The Relationship between Land Use and Intrazonal Trip Making Behaviors: Evidence and Implications*. Washington, DC: Transportation Research Board.

Greenwald, M. J & Boarnet, M. G. (2001). *Built Environment as Determinant of Walking Behavior: Analyzing Nonwork Pedestrian Travel in Portland, Oregon*. Washington, DC: Transportation Research Board.

Guo, J., Bhat, C., & Cooperman, R. (2007). Effect of the Built Environment on Motorized and Non-Motorized Trip Making: Substitutive, Complementary, or Synergistic? *86th Annual Meeting of the Transportation Research Board*, Washington, DC.

Handy, S. L. (1993). Regional Versus Local Accessibility: Implications for Non-Work Travel. *Transportation Research Record 1400*, 58-66.

Handy, S. L. (1996). Methodologies for Exploring the Link between Urban Form and Travel Behavior. *Transportation Research D*, *1*(2), 151-165.

Handy, S. L. (1996). Urban Form and Pedestrian Choices: Study of Austin Neighborhoods. *Transportation Research Record 1552*, 135-144.

Handy, S. L. (2004). *Critical Assessment of the Literature on the Relationships Among Transportation, Land Use, & Physical Activity.* Washington, DC: Transportation Research Board and Institutes of Medicine Committee on Physical Activity, Health, Transportation, & Land Use.

Handy, S L. *Travel Behaviour--Land Use Interactions: An Overview And Assessment Of The Research. In: In Perpetual Motion: Travel Behavior Research Opportunities and Application Challenges*. Elsevier, 2002.

Handy, S. L., Cao, X., & Mokhtarian, P. L. (2006). Self-selection in the relationship between the built environment and walking. *Journal of the American Planning Association*, *72*, 55-74.

Handy, S. L., & Mokhtarian, P. L, & Kwong, K. (2006). *The Role of Attitudes and Neighborhood Characteristics in Explaining Transit Use: A Study of Eight Northern California Neighborhoods*. Washington, DC: Transportation Research Board.

Handy, S. L., Mokhtarian, P. L & Cao, X. (2006).*Does the Built Environment Influence Vehicle Type Choice? Evidence from Northern California*. Washington, DC: Transportation Research Board.

Handy, S., Cao, X., & Mokhtarian, P. L. (2005). Correlation or Causality between the Built Environment and Travel Behavior? Evidence from Northern California. *Transportation Research Part D, 10,* 427–444.

Handy, S.L. & Clifton, K.J. (2001). Local Shopping as a Strategy for Reducing Automobile Travel, *Transportation 28*, 317-346.

Hendricks, Sara, J., et. Al., (2005) *Impacts of Transit Oriented Development on Public Transportation Ridership*. Center for Urban Transportation Research, University of South Florida, Tampa, FL.

*Hensher D A (ed.) Travel Behaviour Research. The Leading Edge*. Elsevier, 2001.

*Hess, P M and Moudon, A V and Logsdon, M G.* MEASURING LAND USE PATTERNS FOR TRANSPORTATION RESEARCH. *Transportation Research Board, 2001.*

Hess, P.M., Moudon, A.V., Snyder, M.C., & Stanilov, K. (1999). Site Design and Pedestrian Travel. *Transportation Research Record 1674*, 9-19.

Hexagon Transportation Consultants. (2002). San Mateo Land Use/Transportation Plan Bay Meadows Phase II Specific Plan: Responses to Traffic Questions.

Hoehner, C. M., Brennan Ramirez, L. K., Elliott, M. B., Handy, S. L., & Brownson, R. C. (2005). Perceived and objective environmental measures and physical activity among urban adults. American Journal of Preventive Medicine, 28, 105-116.

Holtzclaw, J. and Clear, R., Dittmar, H., Goldstein, D., and Haas, P. (2002). "Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Ownership and Use - Studies in Chicago, Los Angeles, and San Francisco, Transportation Planning".

Jin, X and Beimborn, E and Greenwald, M. *Impacts Of Accessibility, Connectivity and Mode Captivity on Transit Choice*. University of Wisconsin, Milwaukee; Federal Transit Administration, 2004.

Johansson, Maria. *Childhood Influences on Adult Travel Mode Choice*. International Conference of Traffic and Transport Psychology, Elsevier, 2005.

Johnston, R.A., Rodier, C. J., Choy, M., & Abraham, J.E. (2000). *Air Quality Impacts of Regional Land Use Policies*. Washington, DC: Prepared for U.S. Environmental Protection Agency, Urban and Economic Development Division.

Kain, J F. *A Tale of Two Cities: Relationships Between Urban Form, Car Ownership and Use and Implications for Public Policy. In: Recent Developments in Transport Economics*. Edward Elgar Publishing Incorporated, 2003.

Kerr, J., Rosenberg, D., Sallis, J. F., Saelens, B. E., Frank, L. D., & Conway, T. L. (2006). Active commuting to school: associations with environment and parental concerns. *Medicine and Science in Sports and Exercise*, *38*, 787-794.

Khattak, A. J. & Rodriguez, D. (2005). Travel behavior in neo-traditional neighborhood developments: A case study in USA. *Transportation Research Part A*, 39, 481-500.

Khattak, A. J. et. al. (2005, February). *Traditional Neighborhood Development Trip Generation Study*. North Carolina Department of Transportation.

Kim, Tae-Gyu and Goulias, Konstadinos G and Burbidge M.A., Shaunna K.. *Travel Behavior Comparisons of Active Living and Inactive Living Lifestyles*. Transportation Research Board, 2006.

Kitamura, R., Akiyama, T., Tamamoto, T., & Golob, T. F. (2001). *Accessibility in a Metropolis: Toward A Better Understanding of Land Use and Travel.* Washington, DC: Transportation Research Board, TRR 1780, 64-75.

Kitamura, R., Mokhtarian, P.L., & Laidet, L. (1997). A Microanalysis of Land Use and Travel in Five Neighborhoods in San Francisco Bay Area. *Transportation*, *24*, 125-158.

Knapp, G. & Song, Y. (2005). The Transportation – Land Use Policy Connection. Chapter 5 In D. Levinson and K. Krizek (Eds.), *Access to Destinations*. London: Elsevier.

Kockelman, K.M. (1995). Which Matters More in Mode Choice: Density or Income? *ITE 1995 Compendium of Technical Papers.* Washington, D.C.: Institute of Transportation Engineers, 844-867.

Kockelman, K.M. (1997). Travel Behavior as a Function of Accessibility, Land Use Mixing, & Land Use Balance: Evidence from the San Francisco Bay Area. *Transportation Research Record 1607*, 116-125.

Krizek, K. J. (2000). A Pre-test/Post-test Strategy for Researching Neighborhood-scale Urban Form and Travel Behavior. *Transportation Research Record, 1722,* 48-55.

Krizek, K. J. (2001). Relationships between Neighborhood-Scale Urban Form, Travel Behavior, & Residential Location Implications for Land Use and Transportation Planning and Policy. *Journal of Planning Literature*, *16*, 397 – 477.

Krizek, K. J. (2003). Planning, Household Travel, & Household Lifestyles. In K.G. Goulias (Ed.) *Transportation Systems Planning: Methods and Applications*. Boca Raton, FL: CRC Press, 6.1-6.42.

Krizek, K. J. (2003). Neighborhood Services, Trip Purpose, & Tour-Based Travel. *Transportation*, 30, 387-410.

Krizek, K. J. (2003). Operationalizing Neighborhood Accessibility for Land Use-Travel Behavior Research and Regional Modeling. *Journal of Planning Education and Research, 22*(3), 270-287.

Krizek, K. J. (2003). Transit Supportive Home Loans: Theory, Application, & Prospects for Smart Growth. *Housing Policy Debate*, 14(4), 657-677.

Krizek, K. J. (2003, Spring). Residential Relocation and Changes in Urban Travel: Does Neighborhood-Scale Urban Form Matter? *Journal of the American Planning Association*, *69*(3), 265-281.

Krizek, K. J. (2005). *Household Lifestyles and Their Relationship to Land-Use and Transportation Planning*. Minneapolis: Humphrey Institute of Public Affairs.

Krizek, K. J. (2005). Perspectives on Accessibility and Travel. In D. Levinson and K. J. Krizek (Eds.), *Access to Destinations* (pp. 109-130). London: Elsevier.

Krizek, K. J. (2006). *Lifestyles, Residential Location Decisions, & Pedestrian and Transit Activity*. Washington, DC: Transportation Research Board, TRR 1981, 171-178.

Krizek, K. J. (2006). The Complexities of Using Land-Use Planning to Affect Travel. In John Brandl (Ed.), *Common Good: Ideas from the Humphrey*, (pp. 31-40). Minneapolis: Humphrey Institute of Public Affairs.

Krizek, K. J. (2006, Summer). Two Approaches to Valuing Some of Bicycle Facilities' Presumed Benefits. *Journal of the American Planning Association*, *72*(3), 309-320.

Krizek, K. J, & P. J. Johnson (2006, Winter). Proximity to Trails and Retail: Effects on Urban Cycling and Walking, *Journal of the American Planning Association*, *72*(1), 33-42.

Krizek, K. J & Roland, R. (2005). What is at the End of the Road? Understanding Discontinuities of On-Street Bicycle Lanes in Urban Settings. *Transportation Research Part D, 10*(1), 55-68.

Krizek, K. J & Waddell, P. (2002). Analysis of Lifestyles Choices: Neighborhood Type, Travel Patterns, & Activity Participation. *Transportation Research Record*, *1807*, 119-128.

Krizek, K. J., El-Geneidy, A., & Thompson, K. (2007). A Detailed Analysis of How an Urban Trail System Affects Cyclists' Travel. Transportation Research Board 86th Annual Meeting.

Kuzmyak, R., Pratt, R., Douglas, G., & Spielberg, F. (2003). Land Use and Site Design. In *Traveler Response to System Changes*, Chapter 15. TCRP Report 95.

Lapham, M. (2001). Transit Oriented Development – Trip Generation and & Mode Split in the Portland Region. Portland State University.

Lawton, T. (1998). Travel Behavior – Some Interesting Viewpoints: The Urban Environment Effects and a Discussion on Travel Time Budget, A Discussion on Selected Data from the 1994/1995 Household Survey, Portland Transportation Summit.

Lee, C & Vernez Moudon, A. (2006). The 3Ds + R: quantifying land use and urban form correlates of walking. *Transportation Research Part D*, *11,* 204-215.

Levinson, D & K. Krizek. (2005). *Access to Destinations.* London: Elsevier, 414.

Levinson, D., Krizek, K. J., & Gillen, D. (2005). The Machine for Access. In D. Levinson and K. J. Krizek (Eds.), Access to Destinations (pp. 1-10). London, UK: Elsevier.

Li, F., Fisher, K. J., Brownson, R. C., & Bosworth, M. (2005). Multilevel modelling of built environment characteristics related to neighbourhood walking activity in older adults. *Journal of Epidemiology and Community Health*, 59, 558-564.

Lin, J & Long, L. *What Neighborhood Are You In? Empirical Findings on Relationships Between Residential Location, Lifestyle, & Travel*. Washington, DC: Transportation Research Board, 2006.

Loutzenheiser, D.R. (1997). Pedestrian Access to Transit: Model of Walk Trips and Their Design and Urban Form Determinants Around Bay Area Rapid Transit Stations. *Transportation Research Record, 1604*, 40-49.

Lund, H. M., & Cervero, R., & Wilson, R. W. (2004). *Travel Characteristics of Transit-Oriented-Development in California.* Pomona, CA: California State University.

Lund, H. (2006). Reasons for Living in a Transit-Oriented Development and Associated Transit Use. *Journal of the American Planning Association*, *72*(3), 357-366.

Lund, H., Willson, R., and Cervero, R. (2006). A Re-Evaluation of Travel Behavior in California TODs. *Journal of Architecture and Planning Research*, 23(3), 247-263.

Maat, K & Timmermans, H. (2007). *The Influence of Land Use on Travel Decisions and the Implications for the Daily Distance Traveled*. *86th Annual Meeting of the Transportation Research Board*, Washington, DC.

Maat, Kees and Timmermans, Harry J P. *Influence of Land Use on Tour Complexity: A Dutch Case*. Transportation Research Board, 2006.

Matsumura, H and Kawata, H. *Socio-Economic Characteristics, Land Use and Travel Patterns*. American Society of Civil Engineers, 2000.

McCormack, E., Rutherford, G. S., & Wilkinson, M. G. (2001). *Travel Impacts of Mixed Land Use Neighborhoods in Seattle, Washington*. Washington, DC: Transportation Research Board.

McCormack, G., B., Giles-Corti, A., Lange, T., Smith, K., Martin, & Pikora, T. J. (2004). An update of recent evidence of the relationship between objective and self-report measures of the physical environment and physical activity behaviours. *Journal of Science and Medicine in Sport*, *7*, 81-92.

McMillan, T. E. (2005). Urban form and a child's trip to school: the current literature and a framework for future research. *Journal of Planning Literature*. *19*, 440-456.

McMillan, T. E. (forthcoming). The relative influence of urban form on a child's travel mode to school. *Transportation Research Part A*.

McNally, M., & Kulkarni, A. Assessment of Influence of Land Use-Transportation System on Travel Behavior. *Transportation Research Record, 1607,* 105-115. Washington, D.C.: Transportation Research Board.

Menotti, V. and Cervero, R. (1995). Transit-Based Housing in California: Profiles. Berkeley: IURD Working Paper 638.

Mesa, J L and Baron, F F. *Socioeconomic Characteristics, Land Use And Travel Patterns: A Profile Of Miami-Dade County*. American Society of Civil Engineers, 2000.

Messenger, T. & Ewing, R. (1996). Transit-Oriented Development in the Sunbelt. *Transportation Research Record, 1552*, 145-152.

Milakis, Dimitris, and Vlastos, Thanos. *Urban Characteristics and Travel Behaviour on the Macro- and Micro- Scale. An Integrated Approach for the Case of Athens*. Paper Presentation at the 11th World Conference on Transportation Research, June 24-28, 2007. University of California, Berkeley.

Miller, E. and Ibrahim, A. (1998). "Urban Form and Vehicular Travel: Some Empirical Findings," Transportation Research Board 77th Annual Meeting.

Newman, P. and Kenworthy, J. (2006). Urban Design to Reduce Automobile Dependence, *Opolis: An International Journal of Suburban and Metropolitan Studies*, 2(1), Article 3.

Noreen C. McDonald, Travel and the social environment: Evidence from Alameda County, California. Transportation Research Part D: Transport and Environment. Volume 12, Issue 1, January 2007, Pages 53-63

Nunes da Silva, F. & de Abreu e Silva, J. (2003). To What Extent Does Urban Density Influence the Modal Split? The Lisbon Metropolitan Area Case Study. In L.J. Sucharov and C.A. Brebbia (Eds.) U*rban Transport IX*. Ashurt, UK: WIT Press.

Ogilvie, D., Egan, M., Hamilton, V., & Petticrew, M. (2004, 22 September). *Promoting walking and cycling as an alternative to using cars: systematic review.* Retrieved June 29, 2004 from doi:10.1136/bmj.38216.714560.55

Parsons, Brinkerhoff, Quade, & Douglas, Cervero, R., Howard/Stein-Hudson Associates, Zupan, J. (1996). TCHRP H1: Part I, Transit Urban Form, and the Built Environment: A Summary of Knowledge. Part II, Commuter and Light Rail Transit Corridors: The Land Use Connection.

Pinjari, A., Pendyala, R., Bhat, C., & Waddell, P. (2007). *Modeling Residential Sorting Effects to Understand the Impact of the Built Environment on Commute Mode Choice*. *86th Annual Meeting of the Transportation Research Board*, Washington, DC.

Plaut, P. O. Non-motorized commuting in the US. (2005). *Transportation Research Part D*, *10*, 347-356.

Polzin, S. (2004). The Relationship between Land Use, Urban Form and Vehicle Miles of Travel. Tampa: Center for Urban Transportation Research, University of South Florida.

City of Portland. (2000). Planning and Zoning Ordinance, Chapter 33.450 "Light Rail Transit Station Zone".

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

Racca, D. P & Ratledge, E. (2003). *Factors that Affect and/or Can Alter Mode Choice*. Prepared for Delaware Transportation Institute and Delaware Department of Transportation.

Rajamani, J., Bhat, C.R., Handy, S., Knaap, G., & Song, Y. (2003) Assessing the impact of urban form measures on nonwork mode choice after controlling for demographic and level-of-service effects. *Transportation Research Record, 1831*, 158-165.

Regional Planning Association. (1997). Building Transit-Friendly Communities (draft).

Regional Plan Association of New York. (1977). Transit Modes Related to Residential Density (table).

Reilly, M.K. (2002). Influence of Urban Form and Land Use on Mode Choice: Evidence from the 1996 Bay Area Travel Survey. 81st Annual Meeting of the Transportation Research Board, Washington, DC.

Rodriguez, D A and Joo, J. *The Relationship Between Non-Motorized Mode Choice And The Local Physical Environment*. Transportation Research Part D, 9, 2: 151-173, Elsevier, 2004.

Rose, M. (2004). *Neighborhood Design & Mode Choice*. Portland, OR: Field Area Paper, Master of Urban and Regional Planning, Portland State University.

Ross, C. and Dunning, A. (1997). Land Use Transportation Interaction: An Examination of the 1995 NPTS Data.

Saelens, B.E., Sallis J.F., & Frank, L.D. (2003). Environmental correlates of walking and cycling: findings from the transportation, urban design, & planning literatures. Annals of Behavioral Medicine, 25(2), 80-91.

Salon, Deborah. *Cars and the City? A Model of the Determinants of Auto Ownership and Use For Commuting in New York City with Endogenous Choice of Residential Location*. Transportation Research Board, 2006.

Scheiner, Joachim. *Housing Mobility and Travel Behaviour: A Process-Oriented Approach to Spatial Mobility: Evidence from a New Research Field in Germany*. Elsevier, 2006.

Schneider, Robert James and Rodriguez, Daniel A. and Young, Hannah M.. *Easy-to-Compute Index for Identifying Built Environments That Support Walking*. Transportation Research Board, 2006.

Schwanen, T. & Mokhtarian, P. L. (2005). *What Affects Commute Mode Choice: Neighborhood Physical Structure or Preferences toward Neighborhoods?* London: Elsevier.

Seattle METRO (Municipality of Metropolitan Seattle). (1997). Encouraging Public Transportation Through Effective Land Use Actions (DOT-I-87-5), 1987. United States Department of Transportation.

Shay, E. & Khattak, A. J. (2005). *Automobile Ownership and Use in Neotraditional and Conventional Neighborhoods*. Washington, DC: Transportation Research Board. TRR 1902, 18-25.

Shay, E., Fan, Y., Rodriguez, D. A., & Khattak, A. J. (2006). *Drive or Walk? Utilitarian Trips Within a Neotraditional Neighborhood*. Washington, DC: Transportation Research Board. TRR 1985, 1-15.

Shriver, K. (1996). Influence of environmental design on pedestrian travel behavior in four Austin neighborhoods. *Transportation Research Record, 1578*, 64-75.

Sirard, J. R., Ainsworth, B. E., McIver, K. L., & Pate, R. R. (2005). Prevalence of active commuting at urban and suburban elementary schools in Columbia, SC. *American Journal of Public Health*, *95*, 236-237.

Smart Growth and Transportation: Issues and Lessons Learned: Report of a Conference. (2005). Conference Proceedings 32. Washington, DC: Transportation Research Board.

Snohomish County Transportation Authority. (1989). A Guide to Land Use and Public Transportation for Snohomish County, Washington, United States Department of Transportation, pp 3-1:3-9.

Soltani, A. & Allan, A. (2006, September). Analyzing the Impacts of Microscale Urban Attributes on Travel: Evidence from Suburban Adelaide, Australia. *Journal of Urban Planning and Development*, *132*(3), 132-137.

Southworth, F. (2001). On the Potential Impacts of Land Use Change Policies on Automobile Vehicle Miles of Travel. *Energy Policy, 29*, 1271-1283.

Spillar, R. and Rutherford, G. (1990). "The Effects of Population Density and Income on Per Capita Transit Ridership in Western American Cities," ITE 1990 Compendium of Technical Papers, pp. 327-331.

Srinivasan, S. & Ferreira, J. (2002). Travel behavior at the household level: Understanding linkages with residential choice. *Transportation Research D*, 7, 225-242.

Srinivasan, S. (2001). *Quantifying Spatial Characteristics for Travel Behavior Models*. Washington, DC: Transportation Research Board.

Srinivasan, S. (2005). *Influence of Residential Location on Travel Behavior of Women in Chennai, India*. Washington, DC: Transportation Research Board.

Steiner, R. L., Wright, S. A., & Paul, J. B. (2000). *Travel in New Urbanist and Traditional Communities: A Case Study of Downtown Orlando, Volume I: Final Report and Appendix A*. Tallahassee: Florida Department of Transportation.

Still, K, Seskin, S. and Parker, T. (2000). "Chapter 3: How Does TOD Affect Travel and Transit Use," Caltrans Statewide Transit-Oriented Development Study, pp. 46-50.

Susilo, Y. & Maat, K. (2007). The Influence of the Built Environment on Trends in Commuting Journeys in the Netherlands. *86th Annual Meeting of the Transportation Research Board*, Washington, DC.

Tilahun, N., Levinson, D. M., & Krizek, K. J. (2007). Trails, Lanes, or Traffic: The Value of Different Bicycle Facilities Using an Adaptive Stated Preference Survey. *Transportation Research Part A, 41*,.287-301.

Timperio, A., Ball, K., Salmon, J., Roberts, R., Giles-Corti, B., Simmons, D., Baur, L. A., & Crawford, D. (2006). Personal, family, social, & environmental correlates of active commuting to school. *American Journal of Preventive Medicine*, *30,* 45-51.

Trans Systems, et. al. (2007) *Elements Needed to Create High Ridership Transit Systems*. Transit Cooperative Research Program, Transportation Research Board, Washington, DC.

TRB, Transit Cooperative Research Program (TCRP) Report 73: Characteristics of Urban Travel Demand, 2000

TRB, Transit Cooperative Research Program (TCRP) Report 95: Chapter 15 – Land Use and Site Design, 2003

Troped, P.J., Saunders, R.P., Pate, R.R., Reininger, B., Addy, C.L. (2003). Correlates of recreational and transportation physical activity among adults in a New England community. *Preventive Medicine,* 37, 304–310.

Urbitran Associates, Inc., et al. (2006) *Guidebook for Evaluating, Selecting, and Implementing Suburban Transit Services*. Transit Cooperative Research Program, Transportation Research Board. Washington, DC.

U.S. DOT. (1986). Personal Travel in the U.S. Volume II: A Report of Findings from the 1983-84 Nationwide Personal Transportation Study.

Untermann, R. (1984). Accommodating the Pedestrian.

Waling, H. *Socio-Economic Land Use and Travel Patterns in Amsterdam*. American Society of Civil Engineers, 2000.

Walters, G. and Cervero, R. (2003). Forecasting Transit Demand in a Fast Growing Corridor: The Direct-Ridership Model Approach, Fehrs and Peers Associates.

Weiner, E and Gorham, R. *Land Use--Transportation Interactions: Workshop Report. In: In Perpetual Motion: Travel Behavior Research Opportunities and Application Challenges*. Elsevier, 2002.

Zegras, P.C. (2004). The influence of land use on travel behavior: Empirical evidence from Santiago de Chile. *83rd Annual Meeting of the Transportation Research Board*, Washington, DC.

Zegras, P.C. (2006). *The Built Environment and Motor Vehicle Ownership and Use: Evidence from Santiago de Chile*. Paper #07-3034. Washington, DC: Transportation Research Board.

Zhang, M. (2004). The role of land use in travel mode choice: Evidence from Boston and Hong Kong. *Journal of the American Planning Association, 70*(3), 344-360.

Zhang, M. (2005). *Intercity Variations in the Relationship Between Urban Form and Automobile Dependence: Disaggregate Analyses of Boston, Massachusetts; Portland, Oregon; and Houston, Texas*. TRR 1902. Washington, DC: Transportation Research Board.

Zlot, A. I & Schmid, T. L. (2005). Relationships among community characteristics and walking and bicycling for transportation and recreation. *American Journal of Health Promotion*,19, 314-317.

# ANNOTATED BIBLIOGRAPHY

## ANNOTATED BIBLIOGRAPHY (Partial):

Anderson, Michael David and Sharfi, Khalid and Gholston, Sampson. *Direct Demand Forecasting Model for Small Urban Communities Using Multiple Linear Regression*. Transportation Research Board, 2006.

Forecasting traffic volumes to support infrastructure decisions is the heart of the travel demand modeling process. The most commonly used methodology for obtaining these forecasted traffic volumes is the four-step process that considers generation, distribution, mode choice, and route assignment of trips. Each step of the process is performed independently, almost always through the use of computer software, to achieve the final traffic volumes. This paper examines the possibility of forecasting traffic volumes by using a multiple linear regression model to perform what is termed direct demand forecasting. The direct demand forecasting model generates traffic volumes for roadways through the development of a functional relationship between roadway characteristics and socioeconomic influences. A direct demand travel forecasting model has been developed and applied, with a small urban area as a case study community. Results are consistent with those obtained from the traditional four-step methodology.

de Abreu e Silva, João and Golob, Thomas F and Goulias, Konstadinos G. Effects of Land Use Characteristics on Residence and Employment Location and Travel Behavior of Urban Adult Workers. Transportation Research Board, TRR 1977, 2006.

The relationships between socioeconomic and demographic characteristics, land use characteristics around the residence and work locations, and a variety of travel behavior indicators are examined by using a structural equations model. This simultaneous equations system allows one to model the effects of land use characteristics on travel behavior while controlling for self-selection bias: certain types of persons choose to live and work in areas that suit their lifestyles and resources. In the model, travel behavior choices are multidimensional; total time away from home, trips and trip distances by three types of modes, car ownership, and possession of a transit pass are included. Land use is captured in geographic information system-based measures of land use and transport supply variables centered on both home and work locations. These measures are reduced to eight land use factors. The analysis provides strong evidence in favor of using land use and urban form designs and planning both around residential neighborhoods and workplace areas. Results provide quantitative evidence of the extent to which workers living in denser, central, compact, and mixed zones make more intense use of transit and nonmotorized modes and tend to have lower car ownership levels. Workers in areas well served by freeways tend to make more intense use of their cars, although this does not inhibit use of transit. The results show that land use measures differ in their ability to explain different travel demands even when controlling for socioeconomic and demographic effects.

Bagley, M. & Mokhtarian, P. (2002). The Impact of Residential Neighborhood Type on Travel Behavior: A Structural Equations Modeling Approach. *Annals of Regional Science*, *36*, 279-297.

In this paper, the authors examine the relationship of residential neighborhood type to travel behavior, incorporating attitudinal lifestyle, and demographic variables. The variable are drawn from data collected from residents of five neighborhoods in the San Francisco Bay Area in 1993.

Barnes, G. (2001). *Population and Employment Density and Travel Behavior in Large U.S. Cities*. Minneapolis: Minnesota Department of Transportation.

This research project sought to determine whether high-population density or some other aggregate land use characteristic can be used to create beneficial effects on travel behavior at the level of the entire urbanized area. The research also looked at gaining a better understanding of the reasons for variations in travel behavior across large U.S. cities. This research involved a comprehensive analysis, considering an unusually large number of factors. Researchers also developed a number of ways to describe aggregate "macro" land use in an urbanized area specifically for this study. The study found that land use, at the aggregate level studied in this project, is not a major leverage point in determining overall population travel choices. Much policy seems to be based on the belief that relatively small changes to land use will have a big impact on travel choices. The findings here imply

just the opposite - that even very big, widespread differences in land use have very little impact on travel behavior, in good ways or in bad ways.

Bhat, C. R and Guo, J. Y. (2006). *Comprehensive Analysis of Built Environment Characteristics on Household Residential Choice and Automobile Ownership Levels*. Washington, DC: Transportation Research Board.

This research paper identifies the research designs and methodologies that may be used to test the presence of ?true? causality versus residential sorting-based ?spurious? associations in the land-use transportation connection. The paper then develops a methodological formulation to control for residential sorting effects in the analysis of the effect of built environment attributes on travel behavior-related choices. The formulation is applied to comprehensively examine the impact of the built environment, transportation network attributes, and demographic characteristics on residential choice and car ownership decisions. The model formulation takes the form of a joint mixed multinomial logit-ordered response structure that accommodates differential sensitivity to the built environment and transportation network variables due to both demographic and unobserved household attributes and controls for the self-selection of individuals into neighborhoods based on car ownership preferences stemming from both demographic characteristics and unobserved household factors. The analysis in the paper represents, to our knowledge, the first instance of the formulation and application of a unified mixed multinomial logit-ordered response structure in the econometric literature. The empirical analysis in the paper is based on the residential choice and car ownership decisions of San Francisco Bay area residents.

Boarnet, M and Crane, R. (2001, November). The Influence of Land Use on Travel Behavior: Specification and Estimation Strategies. *Transportation Research Part A: Policy and* Practice, *35*(9), 823-845.

Even though the relationship between urban form and travel behavior is a key element of many current planning initiatives aimed at reducing car travel, the literature faces 2 major problems. First, this relationship is extremely complex, and second, several specification and estimation issues are poorly addressed in prior work, possibly generating biased results. In this paper, the authors argue that many of the latter problems are overcome by systematically isolating the separable influences of urban design characteristics on travel and then properly analyzing individual-level data. The results that directly follow from alternative land use arrangements, as well as those that do not, are then clarified, thus identifying specific hypotheses to be tested against the data. More reliable tests of these hypotheses are then developed, and implications of alternative behavioral assumptions regarding travel costs are explored. The measured influence of land use on travel behavior is shown to be very sensitive to the form of the empirical strategy.

Boarnet, M & Crane, R. (2001). *Travel by Design: The Influence of Urban Form on Travel*. New York: Oxford University Press.

Combining urban design and transportation planning with the idea that neighborhoods and cities can be designed to change travel behavior is a popular idea. The goal is to reduce car use and increase the quality of life in the neighborhood. This book looks into the premise of urban design and transportation planning. It seeks to answer three questions: Can it work, Will it be put into practice, and Is it a good idea? The book is divided into four parts: an introduction, a section on travel behavior, a section on the supply of place, and a section on the role of travel by design. Topics include traffic, urban form, travel, demand for travel, a study of travel behavior, neighborhood supply, mathematical models for trip generation, transit-oriented planning, and a case study of planning.

Cao, X., Mokhtarian, P. L., & Handy, S. L. (2006). Neighborhood Design and Vehicle Type Choice: Evidence from Northern California*. Transportation Research Part D, 11,* 133–145.

Previous studies have found that suburban development is associated with the unbalanced choice of light duty trucks. The specific aspects of the built environment that influence vehicle choice, however, have not been well-established. Further, these studies have not shed much light on the underlying direction of causality: whether neighborhood designs themselves, as opposed to preferences for neighborhood characteristics or attitudes towards travel, more strongly influence individuals' decisions regarding vehicle type. Using a sample from Northern California, this study investigated the relationship between neighborhood design and vehicle type choice, controlling for residential self-

selection. Correlation analyses showed that neighborhood design has a strong association with vehicle type choice. Specifically, traditional neighborhood designs are correlated with the choice of passenger cars, while suburban designs are associated with the choice of light duty trucks. The nested logit model suggests that sociodemographic and attitudinal factors play an important role, and that an outdoor spaciousness measure (based on perceptions of yard sizes and off-street parking availability) and commute distance also impact vehicle type choice after controlling for those other influences. This study, therefore, supports the premise that land use policies have at least some potential to reduce the choice of light duty trucks, thereby reducing emissions.

Cao, X., Mokhtarian, P. L., & Handy, S. L. (2006). *Impacts of the Built Environment and Residential Self-Selection on Nonwork Travel: Seemingly Unrelated Regression Approach*. Washington, DC: Transportation Research Board.

Many studies have found that residents living in suburban neighborhoods drive more and walk less than their counterparts in traditional neighborhoods. This evidence provides support to the idea of using smart growth strategies to alter individuals' travel behavior. However, the observed differences in travel behavior may be more of a residential choice than a travel choice. Applying seemingly unrelated regression to a sample from Northern California, we explored the relationship between the built environment and nonwork travel behavior, controlling for measures of residential self-selection. This study shows that, at the neighborhood level, individuals' non-motorized travel is greatly influenced by residential self-selection, and residential preference and travel attitudes provide an incremental contribution in explaining the variation in auto and transit travel. After accounting for the influence of self-selection, we also found that neighborhood characteristics themselves affect individuals' travel choices. Therefore, if cities use land use policies to offer residents opportunities to drive less and use alternative modes more, the evidence suggests that they will tend to do so.

Cao, X., Handy, S. L., & Mokhtarian, P. L. (2006). The influences of built environment and residential self-selection on pedestrian behavior: evidence from Austin, TX. *Transportation, 33*, 1-20.

Planners and public health officials are encouraging policies that improve the quality of the built environment for pedestrians: mixed land uses, interconnected street networks, sidewalks, and other facilities. Whether such policies will prove effective partly depends on two issues. First, the impact of the built environment on pedestrian behavior may depend on the purpose of the trip, whether for utilitarian or recreational purposes. Second, the connection between the built environment and pedestrian behavior may be more a matter of residential location choice than of travel choice. This study aims to provide new evidence on both questions. Using information from a 1995 survey conducted in six neighborhoods in Austin, TX, two separate negative binomial models were estimated for the frequencies of strolling trips and pedestrian shopping trips within neighborhoods. An overview of average frequencies for both types of travel in these neighborhoods shows that strolling trips account for the majority of total walking trips made by respondents. Findings suggest that although residential self-selection impacts both types of trips, it is the most important factor explaining walking to a destination, i.e. for shopping. After accounting for self-selection, neighborhood characteristics (especially perceptions of these characteristics) impact strolling frequency, while characteristics of local commercial areas are important in facilitating shopping trips. This result implies that strolling trips and shopping trips are influenced by different dimensions of the built environment.

Cao, Xinyu, Mokhtarian, Patricai L., and Handy, Susan L. (2007) *Do Changes in Neighborhood Characteristics Lead to Changes in Travel Behavior?* Paper Presentation at the 11th World Conference on Transportation Research, June 24-28, 2007. University of California, Berkeley.

Suburban sprawl has been widely criticized for its contribution to auto dependence. Numerous studies have found that residents in suburban neighborhoods drive more and walk less than their counterparts in traditional environments. However, most studies confirm only an association between the built environment and travel behavior, and have yet to establish the predominant underlying causal link: whether neighborhood design independently influences travel behavior or whether preferences for travel options affect residential choice. That is, residential self-selection may be at work. A few studies have recently addressed the influence of self-selection. However, our understanding on the causality issue is still immature. To address this issue, this study took into account individuals' self-selection by employing a quasi-longitudinal design and by controlling for

residential preferences and travel attitudes. In particular, using data collected from 547 movers currently living in four traditional neighborhoods and four suburban neighborhoods in Northern California, we developed a Structural Equations Model to investigate the relationships among changes in the built environment, changes in auto ownership, and changes in travel behavior. The results provide some encouragement that land-use policies designed to put residents closer to destinations and provide them with alternative transportation options will actually lead to less driving and more walking.

Cervero, R. (1993). Ridership Impacts of Transit-Focused Development in California. Berkeley: Report to the California Department of Transportation, IURD Monograph.

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

Cervero, R. (1994). Rail-Oriented Office Development in California: How Successful? *Transportation Quarterly*, *48*, 33-44.

Can transit-focused development lure significant number of Californians out of their cars? This paper explores this question by examining the ridership impacts of existing large-scale office projects near stations of five rail transit systems in the state--Bay Area Rapid Transit (BART), Santa Clara Light Rail Transit, Peninsula CalTrain, Sacramento Regional Transit and San Diego Trolley. Among California's urban rail systems, these have been in operation the longest and thus provide a context for studying the ridership impacts of office developments around more mature station environments. In addition to documenting transit ridership impacts, this paper also identifies key factors that influence the modal choices of station-area office workers. The effects of the built environment--such as density and land-use mixtures--on rail modal splits are also studied.

Cervero, R. (1995). Rail Access Modes and Catchment Areas for the BART System. BART @ 20 Study, IURD, Monograph 50.

The purpose of this report is to provide a 20-year perspective into the land use impacts of BART. The analysis concentrates on historical changes in private residential and non-residential land development for a sample of stations on various segments of the BART system. This report concentrates on documenting land use changes around specific stations and generalizing about the land use impacts of BART among classes of stations. For a sample of stations, differences in land use changes around BART stations and matched pairs of nearby freeway interchanges are also compared. Models are also presented that identify factors associated with station-area land-use changes. The report concludes by merging the results of individual station-area studies, and drawing policy inferences from these findings.

Cervero, R. (1996). Mixed Land-Uses and Commuting: Evidence from the American Housing Survey. *Transportation Research A*, 30, 361-377.

This paper investigates how mixed land-uses influence the commuting choices of residents from large metropolitan areas using data from the 1985 American Housing Survey. The analysis examines the effects of mixed-use levels as well as other features of the built environment like residential densities on three measures of transportation demand: commuting mode choice, commuting distance and household vehicle ownership levels. The effects of land-use environments on mode choice are modeled using binomial logit analysis.

Cervero, R. (2001). Walk-and-Ride: Factors Influencing Pedestrian Access to Transit, *Journal of Public Transportation*, 3(4), 1-23.

The article discusses the problems pedestrians face in trying to gain access to transit, as the predominant means of reaching suburban transit stations in the United States is by private car. In this article, analyses are carried out at two resolutions to address the problem: San Francisco Bay Area's compact, mixed-use settings with minimal obstructions that are conductive to walk-and-ride rail patronage; and Montgomery County, Maryland's urban design with sidewalk provisions and street dimensions that significantly aid access to transit by foot. The paper presents elasticities that summarize findings.

Cervero, R. (2002, June), Built Environments and Mode Choice: Toward a Normative Framework. *Transportation Research Part D: Transport and Environment, 7*(4), 265-284.

Many studies contend that compact, mixed-use, pedestrian friendly urban development can significantly influence mode choice. However, most of these studies have failed to adequately specify relationships for purposes of drawing inferences about the importance of built-environmental factors in shaping mode choice. This paper seeks to overcome some of the deficiencies of past mode-choice analyses through an expanded specification of mode-choice utility. Mode choice in Montgomery County, Maryland is considered around a normative model that weighs the influences of not only three core dimensions of build environments (density, diversity and design) but factors related to generalized cost and socioeconomic attributes of travelers as well. The marginal contributions of built-environment factors to a traditionally specified utility-based model of mode choice are measured. The analysis reveals intensities and mixtures of land use significantly influence decisions to drive alone, share a ride or use public transit, while the influences of urban design tend to be less significant. Elasticities that summarize relationships are also presented. Results indicate that land-use variables should be explicitly included in the utility expressions of mode choice models in urban settings. It is also important to include economic attributes such as travel time and price variables of competing modes in the specification of models that test the influences of land-use factors on travel demand.

Cervero, R. (2006). Alternative Approaches to Modeling the Travel-Demand Impacts of Smart Growth. *Journal of the American Planning Association, 72*(3), 285-295.

Although planners have often used traditional four-step travel demand forecasting models to estimate the travel impacts of smart growth, they are not really appropriate for estimating the travel impacts of neighborhood-scale projects or development near transit stops. This article presents some alternatives to traditional modeling of neighborhood-scale transportation projects, including the direct (or off-line) modeling approach. Examples are presented of direct modeling of rail and transit-oriented land use proposals for the Charlotte, North Carolina metropolitan area, the San Francisco Bay Area, and south St. Louis County in Missouri. Results indicate that concentrating development near rail stations produced an appreciable jump in ridership. These applications also demonstrate that the alternative modeling approaches are well-suited for producing orders-of-magnitude estimates of the travel demand effects of smart growth scenarios and are useful supplements to traditional four-step models.

Cervero, R. (2006). Office Development, Rail Transit, and Commuting Choices, *Journal of Public Transportation*, 9(5), 41-55.

Decentralized employment growth has cut into transit ridership across the United States. In California, about 20% of those working in office buildings near rail stations regularly commute by transit, nearly 3 times transit's modal share among those working away from rail stations. Mode choice models reveal that office workers are most likely to rail-commute if frequent feeder bus services are available, employers help cover the cost of taking transit, and parking is in short supply. However, factors such as trip-chaining and absence of restaurants and retail shops near suburban offices deter transit-commuting. Policymakers can promote transit-commuting to offices near rail stops by flexing parking standards, introducing high-quality feeder buses, and initiating workplace incentives such as deeply discounted transit passes. While housing has generally been the focus of transit-oriented development, unless the workplace end of the commute trip is also convenient to transit, transit will continue to struggle in winning over commuters in an environment of increasingly decentralized employment growth.

Cervero, R & Duncan, M. (2006). Which Reduces Vehicle Travel More: Jobs-Housing Balance or Retail-Housing Mixing? *Journal of the American Planning Association*, *72*(4), 475-490.

This paper investigates which land-use strategy yields the greatest reductions in vehicular travel: improving the proximity of jobs to housing, or bringing retail services closer to residential areas. Using data from the San Francisco Bay Area, the degree to which job accessibility is associated with reduced work travel is examined. In addition, the correlation of retail and service accessibility with mile sand hours spent getting to shopping destinations is probed. Findings show that the jobs-housing balance more successfully reduces travel. However, the vehicle miles traveled and vehicle hours traveled reduction elasticities for both polices were estimated to be well above zero, suggesting

that pursuing both strategies could yield benefits in many settings. Local and regional initiatives to balance the growth of jobs and housing are discussed.

Cervero, R. & Duncan, M. (2002). Residential Self Selection and Rail Commuting: A Nested Logit Analysis. Berkeley: UCTC Working Paper; http://www.uctc.net/papers/604.pdf

In this article, the authors examine the influence of transit-based housing on rail commuting in the San Francisco Bay Area. Using a logit formulation, factors such as travel times of competing modes and demographic characteristics of trip-makers are used for predicting the probabilities that residents opt for rail transit to reach their workplaces. The authors focus on improving upon model specifications by strongly rooting their analysis in urban location theory. They hypothesize that the decision to commute by rail can be significantly explained by residential choice.

Cervero, R. and Duncan, M. (2006). Which Reduces Vehicle Travel More: Jobs-Housing Balance or Retail-Housing Mixing? *Journal of the American Planning Association*, 72(4), 475-490.

This paper investigates which land-use strategy yields the greatest reductions in vehicular travel: improving the proximity of jobs to housing, or bringing retail services closer to residential areas. Using data from the San Francisco Bay Area, the degree to which job accessibility is associated with reduced work travel is examined. In addition, the correlation of retail and service accessibility with mile sand hours spent getting to shopping destinations is probed. Findings show that the jobs-housing balance more successfully reduces travel. However, the vehicle miles traveled and vehicle hours traveled reduction elasticities for both polices were estimated to be well above zero, suggesting that pursuing both strategies could yield benefits in many settings. Local and regional initiatives to balance the growth of jobs and housing are discussed.

Cervero, R and Ewing, R. (2002). Travel and the Built Environment-Synthesis, University of California at Berkeley Institute of Urban and Regional Development.

The potential to moderate travel demand through changes in the built environment is the subject of more than 50 recent empirical studies. The majority of recent studies are summarized. Elasticities of travel demand with respect to density, diversity, design, and regional accessibility are then derived from selected studies. These elasticity values may be useful in travel forecasting and sketch planning and have already been incorporated into one sketch planning tool, the Environmental Protection Agency's Smart Growth Index model. In weighing the evidence, what can be said, with a degree of certainty, about the effects of built environments on key transportation "outcome" variables: trip frequency, trip length, mode choice, and composite measures of travel demand, vehicle miles traveled (VMT) and vehicle hours traveled ((VHT)? Trip frequencies have attracted considerable academic interest of late. They appear to be primarily a function of socioeconomic characteristics of travelers and secondarily a function of the built environment. Trip lengths have received relatively little attention, which may account for the various degrees of importance attributed to the built environment in recent studies. Trip lengths are primarily a function of the built environment and secondarily a function of socioeconomic characteristics. Mode choices have received the most intensive study over the decades. Mode choices depend on both the built environment and socioeconomics (although they probably depend more on the latter). Studies of overall VMT or VHT find the built environment to be much more significant, a product of the differential trip lengths that factor into calculations of VMT and VHT.

Cervero, R & Gorham, R. (1995). Commuting in Transit Versus Automobile Neighborhoods. *Journal of the American Planning Association*, *61(1)*, 210-225.

A recent shift in the suburbs from automobile dependence to transit accessibility, walking, and bicycling is occurring nationwide. This article compares commuting characteristics of transit-oriented and auto-oriented suburban neighborhoods in the San Francisco Bay Area and in Southern California. Researchers found that transit neighborhoods averaged higher densities and had more gridded street patterns compared to their auto-oriented counterparts. Neighborhoods were matched in terms of median incomes and, to the extent possible, transit service levels, to control for these effects. For both metropolitan areas, pedestrian modal shares and trip generation rates tended to be considerably higher in transit than in auto-oriented neighborhoods. Transit neighborhoods had significantly higher rates of bus commuting only in the Bay Area. Islands of transit-oriented

neighborhoods surrounded by freeway-oriented suburbs seem to have negligible effects on transit commuting.

Cervero, R & Kockelman, K. (1997). Travel Demand and the 3Ds: Density, Diversity, & Design. *Transportation Research D*, *2*, 199-219.

This paper examines the connection between the 3Ds of the built environment and travel demand. Notably, it tries to sort through the relative influences of the three dimensions after controlling for other explainers, like travellers' demographic characteristics. It does this mainly by applying the technique of factor analysis to gauge the relative influence of each dimension as well as their collective impacts. The paper tests the propositions of the new urbanists and others that compact neighborhoods, mixed land uses, and pedestrian-friendly designs 'degenerate' vehicle trips and encourage residents to walk, bike, or take transit as substitutes for automobile travel, particularly for non-work purposes.

Cervero, R., Landis, J., and Hall, P. (1992). Transit Joint Development in the United States: A Review of Recent Experiences and an Assessment of Future Potential. Washington: Urban Mass Transportation Administration, U.S. Department of Transportation; Monograph 42, Institute of Urban and Regional Development.

This report reviews transit-linked development in over two dozen U.S> cities, the history of joint development, and the evolving role of the Federal Transit Administration. The report attempts to classify and catalogue existing joint-development projects by size, type, location, and year of completion. Included as an appendix are brief description of the more than one hundred existing U.S. joint-development projects. An analysis was made on the financial impact joint development has had on the capital budgets of transit agencies that pursue joint development and the policy framework in which it occurs. In addition, the study presents the results of a survey of transit officials responsible for negotiating joint development agreements and their appraisal of its effect on their agency's operating and financial performance as well as other goals. The study concludes with an assessment of the institutional and market conditions necessary for successful joint development and recommendations to FTA for promoting and facilitating local joint-development efforts.

Cervero, R & Seskin, S. (1995). *An Evaluation of the Relationships Between Transit and Urban Form*. Washington, D.C: Transit Cooperative Research Program, Transportation Research Board.

This TCRP Digest summarizes the results of Phase I of TCRP Project H-1, "An Evaluation of the Relationships Between Transit and Urban Form". The objectives of this phase were to 1) review the existing literature on transit and urban form relations, 2) develop a framework to synthesize this knowledge, 3) identify gaps in current knowledge, and 4) develop the research plan for the balance of the project. This Digest, which brings together the results of more than 30 years of theoretical and practical examinations of transit and urban form relationships, provides a base of knowledge for future planning and decision making. The research plan will be implemented in Phase II. The contents of this Digest are organized as follows: (1.1) Introduction; (1.2) The Changing Urban Form of North American Cities; (1.3) Transit Impacts on Urban Form and Land Use; (1.4) Urban Form and Land-Use Impacts on Transit Demand; (1.5) Interactive Impacts of Transit and Urban Form; and (1.6) Research in Progress. A Bibliography is included.

Cervero, R., et. al. (2004). *Transit Oriented Development in the United States: Experiences, Challenges, Prospects*. TCRP Report 102.

Focusing development around transit facilities has become a significant way to improve accessibility, support community and regional goals of enhancing the quality of life, and support the financial success of transit investment. The experiences of a new generation of transit systems highlight the powerful role that transit investments play in channeling urban development. Benefits attributable to transit-oriented development (TOD) initiatives include improved air quality, preservation of open space, pedestrian-friendly environments, increased ridership and revenue, reduction of urban sprawl, and reorientation of urban development patterns around both rail and bus transit facilities. Today, many transit systems and communities across the country are participating in TOD programs. TOD participants range from small local and intercity bus systems with community-related services to large local and intercity rail systems with numerous projects. Increasingly, transit agencies are looking at programs and analyzing real-estate competitiveness to solicit developer interest. This report defines

TOD and joint development and offers insight into the various aspects of implementing TOD, including political and institutional factors; planning and land-use strategies, benefits, and impacts; fiscal considerations and partnerships; and design challenges and considerations. The report focuses on TOD and joint development and practice; the level of collaboration between various partners (e.g., the development community, financial partners, planning and land-use agencies, and government entities); the impacts of TOD and joint development on land values; the potential benefits of TOD; and successful design principles and characteristics. This report will be helpful to transit agencies, the development community, and local decision makers considering TOD. Some data on travel behavior is presented, including evidence that grid street networks can increase transit use by as much as 20 percent.

Chapleau, R and Morency, C and Madituc, G. *IMPACTS OF SETTLEMENT PATTERNS AND DYNAMICS ON URBAN MOBILITY BEHAVIOUR: FINDINGS FROM THE ANALYSIS OF MULTIPLE DATA SOURCES*. Elsevier, 2001.

This paper describes how there is a widespread recognition that transportation and land-use are strongly related. Actually, an extensive literature documents our current understanding of relationships linking urban form factors (residential and employment density, transit supply, auto ownership, accessibility and socio-economic factors such as income, age, gender and occupation) with travel activity (travel distances, modal split, mobility rate). Worth mention is a review of literature conducted in 1998 that summarized the current understanding of the implications of land-use on transit and the implications of transit on urban form in terms of influent factors. Noted in this research is the fact that "while transportation and land-use are strongly related, the current means of analyzing this relationship are limited". Urban sprawl, when observed according to its time dynamics, generates strong structural changes in travel behavior for commuters. For metropolitan transportation planners, recent and urgent concerns are emphasizing needs for clarifying the mutual impacts between land-use and transportation networks. In the same context, transport systems analysis at the metropolitan level faces the methodological challenge of accessing, structuring and exploiting relevant information from multiple data sources. This paper defines an analytical framework for modeling the impacts of settlement patterns and related mobility behavior by the incorporation of multi-dimensional variables in order to represent the complexity of the urban process phenomena. The question of forecasting future settlement pattern and related mobility is also addressed. An extensive experimentation with the Montreal data constitutes a demonstration of the applied methodology.

Chatman, D. G. (2003). How Density and Mixed Uses at the Workplace Affect Personal Commercial Travel and Commute Mode Choice. *Transportation Research Board*, TRR 1831.

A high density of shops and services near the workplace may make it easier to carry out personal commercial activities on foot before, during, and after work, enabling reduced vehicle use during the rest of the day. Investigating this question is an important addition to the current research, which has focused on residential neighborhoods. Data from the 1995 Nationwide Personal Transportation Survey are used to investigate the influence of workplace employment density and share of retail employment on commute mode choice and vehicle miles traveled (VMT) to access personal commercial activities. The analysis controls for socioeconomic characteristics and accounts for the endogeneity of commute mode choice and personal commercial VMT by employing a joint logit-Tobit model. Employment density at the workplace is found to be associated with a lower likelihood of automobile commuting and reduced personal commercial VMT, while the presence of employment in the retail category does not play a significant role. Workplace density is more clearly related to reduced VMT and automobile commuting than to characteristics of workers' residential neighborhoods and could have significant influences on personal commercial VMT and automobile commuting when increasing over a large area. The results suggest that land use planners should focus on encouraging employment density to a greater extent than is the current practice, although further research is needed on the role played by correlated factors such as higher parking costs, increased road congestion, and better transit service

Clifton, K. J. & Dill, J. (2005). *Women's Travel Behavior and Land Use: Will New Styles of Neighborhoods Lead to More Women Walking?* Washington, DC: Transportation Research Board.

Many travel behavior researchers have explored the links between land use characteristics and travel patterns. Several of them have demonstrated that certain patterns, such as density, mixed uses, and street connectivity, are associated with fewer or shorter vehicle trips, or both. There is also a considerable body of literature demonstrating the differences between men's and women's travel patterns. Yet less effort has been devoted to examining how land use may interact with sex to influence travel outcomes. If land use does affect travel, does it affect men's and women's travel differently? In particular, will both women and men take advantage of the walkable features of new urbanist neighborhoods? This study examines these questions in more detail through empirical analysis of land use and travel data. The relationships between walking behaviors, land use, and sex are emphasized. The findings reveal that women in new urbanist neighborhoods may walk more than do women in less walkable environments. However, men appear more likely to respond to these environments and walk more than their female counterparts. Land use and urban design may also remove some of the current barriers to women's walking, particularly safety concerns; however, the results indicate that women's ability or inclination to walk may be rooted in other reasons, such as family responsibilities.

Crane, R. (1996) On form versus function: Will the New Urbanism reduce traffic or increase it? *Journal of Planning Education and Research, 15*(3), 117-126.

A major attraction of the popular and influential planning movements known as the new urbanism, transit-oriented development, and neotraditional planning are their presumed transportation benefits. Though the architects and planners promoting these ideas are usually careful to emphasize the many ingredients necessary to obtain desired results--straightening of streets to open the local network, "calming" of traffic, better integration of land uses and densities, and so on -- a growing literature and number of plans feature virtually any combination of these elements as axiomatic improvements. The potential problem is that the traffic impacts of the new plans are generally indeterminate, and it is unclear whether designers understand the reasons well enough to avoid unintended results. This paper proposes a simple behavioral model to identify and assess the tradeoffs these ideas impose on transportation and subdivision planners.

Crane, R. (1996). Cars and Drivers in the New Suburbs: Linking Access to Travel in Neotraditional Planning. *Journal of the American Planning Association*, *62*, 51-65.

Various "new suburb" land-use designs have emerged to address several social and environmental problems, including the dominance of automobile travel. Transportation benefits are expected from reducing the surface street distance between locations, mixing land uses, "calming" traffic, and promoting walking, bicycling, and transit via redesigned streets and streetscapes. The assumption that auto travel will decrease is a largely unchallenged premise of these designs. The evidence that exists on the subject is weak or contrary; this paper presents a simple behavioral argument to explain why. Generally speaking, driving is both discouraged and facilitated in the new suburbs, with the net effect being an empirical matter. The number of automobile trips and vehicle-miles traveled can actually increase with an increase in access, such as a move to a more grid-like land-use pattern. Clearly, the merits of the neotraditional and transit-oriented designs with their transportation benefits have been oversold. Each development must be evaluated as a separate case to determine whether its net impact on auto use is positive or negative.

Crane, R. (2000). The Influence of Urban Form on Travel: An Interpretive Review. *Journal of Planning Literature*, *15*(1), 3-23.

This article explores whether neighborhood design can improve traffic. A scheme is first proposed for categorizing research addressing this and other related issues. Next, a detailed discussion of key studies of urban form and travel behavior is presented. The research strategies employed and the data, methods, and results of these studies are then evaluated in detail. The article concludes that although this body of research is improving in several respects and should be encouraged by policymakers and scholars alike, the current understanding of this complex group of relationships remains tentative. The basis for using land use and urban design to selectively change travel behavior thus appears limited in the near term, whereas research opportunities abound.

Dill, Jennifer. (2003). “Transit Use and Proximity to Rail: Results from Large Employment Sites in the San Francisco Bay Area”, Transportation Research Board Annual Meeting CD-ROM.

Survey data from more than 1,000 large employment sites in the San Francisco Bay Area are used to examine the link between transit use and proximity to rail stations. The data were collected as part of an employer trip-reduction rule. Findings show that sites within one-quarter mile of a rail station have significantly higher rates of transit use than sites between one-quarter and one-half mile from stations. Transit use drops even further one-half mile from stations. That relationship holds true for all three rail systems in the Bay area. A closer look at 20 work sites near two light rail stations in Santa Clara County reveals that actual walking distance is also an important factor related to transit use. However, site design often lengthens walking distance unnecessarily. In addition, certain types of employers have higher rates of transit use than others.

Dill, J. (2006). *Travel and Transit Use at Portland Area Transit-Oriented Developments (TODs)*. TransNow, Department of Civil Engineering, University of Washington, Seattle WA.

In recent years there has been a growing interest in using land use planning to reduce reliance on the automobile long-term, through ideas such as smart growth, New Urbanism, pedestrian pockets, and transit-oriented developments (TODs). Many growing regions throughout the United States, are turning to these concepts to address problems of traffic congestion and suburban sprawl. However, the effectiveness of such policies in reducing automobile travel and improving livability is largely unknown. Portland was one of the early adopters and is often pointed to as a model for other regions. The Region's 2040 Growth Concept, adopted by the Metro regional government, includes many smart growth concepts. Metro uses a number of programs and policies to implement the 2040 Growth Concept, including subsidies to TODs. This research surveyed residents of TODs in the Portland area to help answer the following questions: (1) Do residents of TODs drive vehicles less, use transit more, and/or walk and bicycle more than residents of other neighborhoods? (2) To what extent can TODs increase transit ridership? (3) How do features of the TOD influence travel choices? (4) Do the features of TODs induce people to change their travel behavior? Alternatively, are people who move to these neighborhoods already active transit users, walkers, or cyclists, i.e., are they seeking an environment in which to practice their preferred travel behaviors? These questions are key to understanding the cause-effect relationship between the built environment and travel behavior. (5) How do people's attitudes toward travel and their neighborhood influence travel behavior?

DKS Associates, University of California, Irvine, University of California, Santa Barbara and Utah State University. (2007). Assessment of Local Models and Tools for Analyzing Smart-Growth Strategies: Final Report. Prepared for the State of California Business, Transportation and Housing Agency, and California Department of Transportation.

There is a growing interest in California in “smart-growth” land- use and transportation strategies designed to provide mobility options and reduce demand on automobile-oriented facilities. This study focuses on models and tools available for use by cities and counties in California for assessing the potential effects of smart-growth strategies.

The majority of regional agencies and local jurisdictions in California currently use a version of the Urban Transportation Modeling System (UTMS), commonly referred to as the “four-step travel demand model.” This study provides a review of the steps in the UTMS process to identify where sensitivity to smart-growth strategies may be limited during the modeling process, and suggests ways that improvements could be made.

The greatest degree of modeling smart-growth sensitivity was found among UTMS models used by larger Metropolitan Planning Organizations (MPOs) or Congestion Management Agencies (CMAs). Several larger MPOs in California are also implementing new types of models, such as activity-based travel models or integrated land use/economic/transportation models. Some local jurisdictions also already use advanced models or travel demand models with high levels of smart-growth sensitivity. The report suggests that if local jurisdictions are already using models with “moderate” to “high” levels of smart-growth sensitivity, they should continue to enhance their models.

However, many local jurisdictions’ models have very little sensitivity to smart-growth land use or transportation strategies. In such cases, the study suggests the appropriate use of a planning tool and/or post-processing application that incorporates “4D elasticities” (e.g., Density, Diversity, Design and Destinations). The report finds that 4D elasticities tools can be used as part of local planning, public participation, and decision-making processes, such as: reviewing major land-use development

proposals, preparing updates to city and county general plans and specific area community plans, and during regional "visioning" and other public participation processes. Therefore, local jurisdictions with low-sensitivity models should consider using a 4Ds methodology to gain increased sensitivity to smart-growth strategies, either applied in "sketch-planning" software (such as I-PLACE[3] S, INDEX), or as a spreadsheet post-processor to a travel demand model.

However, before a decision is made to implement a 4D elasticities tool, the available travel demand model should first be tested to determine its sensitivity to smart-growth strategies. In addition, the report suggests that methods used to capture smart-growth sensitivity (either via improvements to a travel model and/or supplemental tools) should first be calibrated with local data and tested for reasonableness before being applied.

The report cautions against using 4D elasticities tools for conducting detailed corridor planning of streets or highways, for transportation impact studies of proposed land-use projects or traffic impact fee programs, or for CEQA or NEPA documentation - unless they are applied in specific ways (which are described). Other significant findings, conclusions, and recommendations are provided in Chapter 7.

Eliasson, John and Mattsson, L-G. *A Model for Integrated Analysis of Household Location and Travel Choices*. Transportation Research A 34, 375-394, Elsevier, 2000.

In this paper, the authors develop a model for integrated analysis of household location and travel choices and investigate it from a theoretical point of view. Each household makes a joint choice of location (zone and house type) and a travel pattern that maximizes utility subject to budget and time constraints. Prices for housing are calculated so that demand equals supply in each submarket. The travel pattern consists of a set of expected trip frequencies to various destinations with different modes. Joint time and budget constraints ensure that time and cost sensitivities are consistent throughout the model. Choosing the entire travel pattern at once, as opposed to doing so as a series of isolated choices, allows the marginal utilities of trips to depend on which other trips are made. When choosing trip frequencies to destinations, households are assumed to prefer variation to an extent varying with the purpose of the trip. The travel pattern will tend to be more evenly distributed across trip ends the less similar destinations and individual preferences are. These heterogeneities of destinations and individual preferences, respectively, are expressed in terms of a set of parameters to be estimated.

Ewing, R. (1995). Beyond Density, Mode Choice, & Single-Purpose Trips. *Transportation Quarterly*, *49*, 15-24.

This study investigates the independent effects of land use on house-hold travel behavior, controlling for sociodemographic differences among households. It appears that even in a sprawling sunbelt environment, land use patterns matter. However, their effect is not exactly as envisioned by the advocates. Accessibility to regional activities has much more effect on household travel patterns than does density or land use mix in the immediate area; accessibility has as much effect on the frequency and length of trips as the mode of travel; and these relationships can be best understood in terms of multi-purpose trip making.

Ewing, R & R. Cervero. (2001). Travel and the Built Environment: A Synthesis. *Transportation Research Record, 1780*, 87-114.

The potential to moderate travel demand through changes in the built environment is the subject of more than 50 recent empirical studies. The majority of recent studies are summarized. Elasticities of travel demand with respect to density, diversity, design, and regional accessibility are then derived from selected studies. These elasticity values may be useful in travel forecasting and sketch planning and have already been incorporated into one sketch planning tool, the Environmental Protection Agency's Smart Growth Index model. In weighing the evidence, what can be said, with a degree of certainty, about the effects of built environments on key transportation "outcome" variables: trip frequency, trip length, mode choice, and composite measures of travel demand, vehicle miles traveled (VMT) and vehicle hours traveled ((VHT)? Trip frequencies have attracted considerable academic interest of late. They appear to be primarily a function of socioeconomic characteristics of travelers and secondarily a function of the built environment. Trip lengths have received relatively little

attention, which may account for the various degrees of importance attributed to the built environment in recent studies. Trip lengths are primarily a function of the built environment and secondarily a function of socioeconomic characteristics. Mode choices have received the most intensive study over the decades. Mode choices depend on both the built environment and socioeconomics (although they probably depend more on the latter). Studies of overall VMT or VHT find the built environment to be much more significant, a product of the differential trip lengths that factor into calculations of VMT and VHT.

Ewing, R., DeAnna, M., & Li, S. (1996). Land Use Impacts on Trip Generation Rates. *Transportation Research Record, 1518*, 1-7.

In the conventional four-step travel demand modeling process, the number of trips made by a household is modeled in terms of household size, income, and other sociodemographic variables; any effect of location, land use, or transportation service level is discounted. This is the same as discounting any effect of household accessibility to out-of-home activities as a factor in trip generation (accessibility depending on all three: location, land use, and transportation service level). In contrast to the practice of trip generation, theory tells us that trip rates must vary with accessibility, and some (not all) empirical studies have found that they do. In light of conflicting empirical studies, and the obvious need for more precise and policy-sensitive travel forecasts, this issue is revisited. The independent effects of land use and accessibility variables on household trip rates were tested for using data from Florida travel surveys. It was found that, after controlling for sociodemographic variables, residential density, mixed use, and accessibility do not have significant, independent effects on household trip rates. Conventional trip generation models, which generate person trips by vehicle (not by all modes) and do so without regard to residential location, may not be as bad as one would imagine a priori.

Ewing, R., Dumbaugh, E., & Brown, M. (2001). *Internalizing Travel by Mixing Land Uses: Study of Master-Planned Communities in South Florida*. Washington, DC: Transportation Research Board.

Planners, public officials, and large-scale land developers increasingly promote mixed-use developments as an alternative to sprawl. They list among the benefits of such developments the "internal capture" of trips; that is, trips that would otherwise have filtered onto the regional road network will remain on site. Yet, so little information is available about internal capture rates that traffic impact studies for mixed-use developments become little more than exercises in speculation. In an attempt to advance basic knowledge of the subject and move toward better prediction methods, 20 mixed-use communities in south Florida were studied to determine the effect of land use mix on internal capture rates. The sample of communities studied had internal capture rates ranging from 0 to 57% of all trip ends generated. When modeled in terms of land use and accessibility variables, both the scale of a development and regional accessibility proved significant, with the former directly related to internal capture and the latter inversely related to internal capture. The best-fit model explained just under half of the variance in internal capture rates. Controlling for scale and regional accessibility, land use mix and density did not have independent predictive powers. Whether because of limitations of the data set, model specification, or method of analysis, the benefits of mixed-use development were not borne out.

Ewing, R., Haliyur, P., & Page, G.W. (1994) Getting Around a Traditional City, a Suburban PUD, & Everything In-Between. *Transportation Research Record, 1466*, 53-62.

Beyond some studies relating density to mode choice, vehicle miles of travel, or gasoline consumption, little is known about the relationship of location and land use to household travel patterns. Against this backdrop a 16,000-record travel survey for Palm Beach County, Florida, was analyzed. Six communities were culled from the larger data base, and household travel data were then tested for statistically significant differences in trip frequency, mode choice, trip chaining, trip length, and overall vehicle hours of travel. Households in a sprawling suburb generate almost two-thirds more vehicle hours of travel per person than comparable households in a traditional city. Although travel differences are significant, they are smaller than one might expect given the more than 10-fold difference in accessibility among the communities. Sprawl dwellers compensate for poor accessibility by linking trips of household members in multipurpose tours. Implications for land planning are more complex than simply pedestrianizing or transitizing the suburbs. Communities

should internalize as many facilities and services as possible. This is true even where the automobile reigns supreme. Communities should concentrate facilities and services in centers and corridors. This will facilitate efficient automobile trips and tours. The more sprawling the area, the more important this becomes, for through activity centers, linked accessibility to activities can be maintained even as direct accessibility falls off.

Ewing, R., Pendall, R., & Chen, D. (2003). *Measuring Sprawl and Its Transportation Impacts*. Washington, DC: Transportation Research Board.

Across the United States, urban sprawl, its impacts, and appropriate containment policies have become the most hotly debated issues in urban planning. Today's debates have no anchoring definition of sprawl, which has contributed to their unfocused, dogmatic quality. Efforts to measure sprawl and test for relationships between sprawl and transportation outcomes are described. This is the first use of the newly minted Rutgers-Cornell sprawl indicators. Sprawl is operationalized by combining many variables into a few factors representing density, land use mix, degree of centering, and street accessibility. This consolidation of variables is accomplished with principal component analysis. These factors are then related to vehicle ownership, commute mode choice, commute time, vehicle miles traveled per capita, traffic delay per capita, traffic fatalities per capita, and 8-h ozone level. These associations are made with multiple regression analysis. For most travel and transportation outcomes, sprawling regions perform less well than compact ones. The exceptions are average commute time and annual traffic delay per capita, which do not clearly favor compactness over sprawl. The main limitation of this study has to do with the data it uses. By necessity, the study uses highly aggregate data from a variety of sources that are not always consistent as to the area under study and time period. They are simply the best data available from national sources with sufficient breadth to provide a panoramic view of sprawl in the United States. Results will have to be validated through follow-up work of a more focused nature.

Ewing, R., Handy, S. L., Brownson, R., & Clemente, O. (2006). *Identifying and Measuring Urban Design Qualities Related to Walkability*. Washington, DC: Transportation Research Board.

A growing body of research provides evidence of a link between the built environment and active living. However, to date, the measures used to characterize the built environment have been mostly gross qualities such as neighborhood density and street connectivity (see reviews by Ewing and Cervero 2001; Handy 2004; and Ewing 2005). The urban design literature points to subtler qualities that may influence choices about active travel and active leisure time. These qualities will be referred to as perceptual qualities of the urban environment or, alternately, just as urban design qualities. The urban design literature presumes that these qualities are important for walkability, without much empirical evidence. Until urban design qualities can be measured, this presumption will remain untested.

Fontaine, M D. *Factors Affecting Traveler Mode Choice: A Synthesis of the Literature*. Virginia Transportation Research Council; Virginia Department of Transportation, 2003.

The purpose of this study was to review the literature related to how travelers make mode choice decisions in order to identify factors that influence mode choice and determine possible ways that the Virginia Department of Transportation (VDOT) could alter the mode split. This report does not deal with prediction or modeling of mode splits but rather provides information on what qualities are important to travelers when making mode choice decisions. The literature review revealed several factors that influence the mode choice of a specific traveler: practical availability of mode; connectivity; monetary cost; travel time; trip reliability; trip distance; trip purpose; income; age; and safety. The literature review also revealed several methods that VDOT or other agencies could use to create changes in mode split in the near term: High Occupancy Vehicle (HOV) facilities; park and ride lots; transit fare changes; increased transit frequency; increased transit coverage; and changes in parking price.

Frank, L., Chapman, J., & Bradley, M., & Lawton, T. K. (2005). *Travel Behavior, Emissions & Land Use Correlation Analysis in the Central Puget Sound*. Washington State Department of Transportation.

A growing body of research documents that land use relates with travel mode choice, distances and time spent traveling, and household level vehicle emissions. However, to date little work has been done at a sufficiently disaggregate scale to gain an understanding of how local governments should

alter their land use policies and plans to reduce vehicle use and encourage transit and non-motorized forms of travel. This study of the four county Central Puget Sound region links parcel level land use data with travel data collected from the Puget Sound Household Travel Survey (PSHTS). The primary aim of the study is to describe how measures of land use mix, density, and street connectivity where people live and work influences their trip making patterns including trip chaining and mode choice for home based work trips, home based non-work trips, and mid day trips from work. Land use measures are developed within one km of the household and employment trip ends in the survey. Tour based models are developed to estimate the relative utility of travel across available modes when controlling for level of service, regional accessibility to employment, and socio-demographic factors. A secondary aim of the project is to estimate the linkages between land use and household generations of Oxides of Nitrogen and Volatile Organic Compounds that are precursors to the formation of harmful ozone. Emissions are estimated based on modeled speeds for AM, PM, and off peak travel at the trip link level and then aggregated to the household level. Household emissions are then correlated with land use patterns where people live when controlling for socio-demographic factors. An exploratory analysis was also conducted as part of this work to estimate how land use patterns where people work influences their modal choice and engagement in travel demand management (TDM) programs offered by employers. The project relied on the Commute Trip Reduction Database from Washington State Department of Transportation (WSDOT). However, it was found that additional development of these data is necessary before this type of analysis can be done. Results are presented that document how much of an increase in the utilization of specific modes of travel for work and non-work travel would likely accrue from specific types of land use changes, and from changes to travel cost and travel time.

Gorham, R. *Comparative Neighborhood Travel Analysis: An Approach to Understanding the Relationship between Planning and Travel Behavior. In: In Perpetual Motion: Travel Behavior Research Opportunities and Application Challenges.* Elsevier, 2002.

Within the overall research framework of the relationship between planning and travel behavior, this report attempts to determine the nature of the interaction between the form of human spatial settlements and the travel behavior of people who live in these various settlements. It is the human element that creates the connection; people react to the built environment, take their cues from it, and engage in a number of behaviors (of which travel is only one) that make them comfortable. The challenge then, is for researchers to represent and interpret what it is that people do perceive in the urban environment that influences their travel decisions. This study applied a typological approach to 2 regions—the San Francisco Bay Area and the Stockholm Metropolitan Region—as a way of examining the interaction between urban form and travel behavior in a comparative context.

Giuliano, Genevieve and Hu, His-Hwa and Lee, Kyoung. *Travel Patterns of the Elderly: The Role of Land Use*. METRANS Transportation Center; University of Southern California. School of Policy, Planning, and Development; California Department of Transportation; Dept. of Transportation Research and Special Programs Administration, 2003.

This report presents an examination of the relationships between residential location and travel patterns of the elderly. Using the 1995 Nationwide Personal Transportation Survey, the authors describe travel patterns of the elderly and estimate models of trip making daily travel and transit use. They find that land use and travel relationships are primarily the same for the elderly as for the non-elderly, although it is evident that the oldest elderly may be more sensitive to local accessibility. The authors consider the potential effectiveness of various land use strategies. Promoting more transit-friendly, mixed-use communities may increase local accessibility, but current preference for automobile travel, low-density living environments, and the benefits of aging in place indicate that these types of strategies will have a limited effect in addressing mobility problems of the elderly. Safer vehicles and transportation facilities behavioral adjustments, and development of paratransit options more competitive with the private vehicle may be strategies suitable for addressing mobility of the elderly.

Greenwald, Michael. *Relationship Between Land Use and Trip Internalization Behaviors: Evidence and Implications*. Transportation Research Board, 2006.

This paper addresses the relationship between land use and destination selection, and the question of destination selection on travel mode choice. Specifically, this work focuses on internalized trips, a sub-category of trip making where both trip origin and trip destination are contained in the same geographic unit of analysis. This investigation uses data from the 1994 Household Activity and Travel Diary Survey conducted by Portland Metro. Using multinomial logit and binary logistic models to measure travel mode choice and decision to internalize trips, the evidence here supports three conclusions: 1.) urban design elements do more to alter travel mode choice than alter trip destination; 2.) there is a threshold effect in the ability of mixed use to alter travel behavior; and 3.) greater emphasis to destinations within the area where the home is located needs to be given in trip distribution models.

Greenwald, M. J. (2003). The Road Less Traveled: New Urbanist Inducements to Travel Mode Substitution for Nonwork Trips. *Journal of Planning Education and Research*, 23, (39-57).
This article tests the New Urbanist ideas about travel mode substitution, based on the argument that urban design is deliberately planned to automatically get travelers to substitute walking and transit for personal car use. The article uses data from a 1994 Household Activity and Travel Behavior Survey conducted in Portland, Oregon, to suggest that New Urbanist concepts serve to increase walking substitution, but public transit is not affected. This seems true even when travelers self-select into a specific residential environment.

Greenwald, M. J. (2006). *The Relationship between Land Use and Intrazonal Trip Making Behaviors: Evidence and Implications*. Washington, DC: Transportation Research Board.
Abstract: This paper addresses the relationship between land use, destination selection, and travel mode choice. Specifically, it focuses on intrazonal trips, a sub-category of trip making where both trip origin and trip destination are contained in the same geographic unit of analysis, using data from the 1994 Household Activity and Travel Diary Survey conducted by Portland Metro in Oregon. Using multinomial logit and binary logistic models to measure travel mode choice and decision to internalize trips, the evidence supports the conclusions that (1) intrazonal trips characteristics suggest mode choice for these trips might be influenced by urban form, which in turn affects regional trip distribution; (2) there is a threshold effect in the ability of economic diversity/mixed use to alter travel behavior; and (3) greater emphasis to destinations within the area where an individual?s home is located needs to be given in trip distribution models.

Greenwald, M. J & Boarnet, M. G. (2001). *Built Environment as Determinant of Walking Behavior: Analyzing Nonwork Pedestrian Travel in Portland, Oregon*. Washington, DC: Transportation Research Board.
Much has been written about the connection between land use/urban form and transportation from the perspective of affecting automobile trip generation. This addresses only half the issue. The theoretical advances in land use-transportation relationships embodied in paradigms such as the jobs-housing balance, neotraditional design standards, and transit-oriented development rely very heavily on the generation of pedestrian traffic to realize their proposed benefits. The present analysis uses models and data sets similar to those used in previous work for the Portland, Oregon, area but applies them toward analysis of nonwork walking travel. The results suggest that regardless of the effects that land use has on individual nonwork walking trip generation, the impacts take place at the neighborhood level.

Handy, S. L. (1993). Regional Versus Local Accessibility: Implications for Non-Work Travel. *Transportation Research Record 1400*, 58-66.
The question of how alternative forms of development affect travel patterns has recently been the focus of a heated debate, much of which centers on the effects of suburbanization in particular. The concept of accessibility provides an important tool for resolving this question. By measuring both the accessibility to activity within the community, or "local" accessibility, and the accessibility to regional centers of activity from that community, or "regional" accessibility, the structure of a community is more fully characterized. The research summarized uses the concepts of local and regional accessibility to test the implications for shopping travel of alternative forms of development in a case study of the San Francisco Bay Area. The results show that higher levels of both local and regional accessibility are associated with lower average shopping distances but are not associated with

differences in shopping frequency. As a result, higher levels of both local and regional accessibility are associated with less total shopping travel. However, the effect of high levels of local accessibility is greatest when regional accessibility is low and vice versa. These findings suggest that policies should be directed toward enhancing both types of accessibility, but that the effects may work against each other to some degree.

Handy, S. L. (1996). Methodologies for Exploring the Link between Urban Form and Travel Behavior. *Transportation Research D*, *1*(2), 151-165.

Communities are increasingly looking to urban design and the concept of the New Urbanism as an effective strategy for reducing automobile dependence in suburban areas. This paper reviews alternative approaches for exploring the link between urban form and travel behavior, outlines issues and complexities that this research must address, and, finally, suggests that the focus of this research should shift from the search for strategies to change behavior to a search for strategies to provide choices.

Handy, S. L. (1996). Urban Form and Pedestrian Choices: Study of Austin Neighborhoods. *Transportation Research Record 1552*, 135-144.

Supporters of the New Urbanism suggest that the right design will encourage walking, thereby encouraging interaction and a greater sense of community and discouraging automobile dependence. Existing research provides insufficient evidence to support this belief, however, largely because of limitations in the data and methodologies that researchers have used. The research described moves beyond a simple test of correlations to an exploration of how urban form fits into a more comprehensive model of choices about pedestrian trips. First, a model for individual choices about pedestrian trips is proposed. Second, the results of a study of six neighborhoods in Austin, Texas, are presented. Data from a survey of residents in these neighborhoods support the proposed model and suggest that certain aspects of urban form can play an important role in encouraging walks to a destination but that the savings in travel from the substitution of walking for driving is likely to be small.

Handy, S L. *Travel Behaviour--Land Use Interactions: An Overview and Assessment of the Research. In: In Perpetual Motion: Travel Behavior Research Opportunities and Application Challenges*. Elsevier, 2002.

This report looks at the research to date on the nature of the relationship between travel behavior and land use. The types of research approaches that have been used previously are reviewed, and a long list of issues relevant to this topic that have yet to be adequately addressed are discussed.

Handy, S. L., Cao, X., & Mokhtarian, P. L. (2006). Self-selection in the relationship between the built environment and walking. *Journal of the American Planning Association*, *72*, 55-74.

Previous studies have established correlations, but not a causal relationship, between the built environment and walking. This has led researchers to debate whether "self-section" explains the observed correlations; i.e., if residents who prefer to walk choose to live in more walkable neighborhoods. Using data from a survey of residents of eight neighborhoods in Northern California, this paper presents new evidence on the possibility of a causal relationship between the built environment and walking behavior. The current study improves on previous research by incorporating travel attitudes and neighborhood preferences into the analysis of walking behavior, and by using a quasi-longitudinal design to test the relationship between changes in the built environment and changes in walking. Both analyses show that the built environment has an impact on walking behavior, even after accounting for attitudes and preferences. The implications of these findings for planning and policy are discussed, and directions for future research are suggested.

Handy, S. L., & Mokhtarian, P. L, & Kwong, K. (2006). *The Role of Attitudes and Neighborhood Characteristics in Explaining Transit Use: A Study of Eight Northern California Neighborhoods*. Washington, DC: Transportation Research Board.

This paper describes how transit ridership has been declining since its peak during World War II, and automobile use has been increasing. Efforts to lessen automobile dependence by improving transit service have seen limited success: outside of major urban centers, most individuals who have the option to drive choose to drive. Nevertheless, some do choose transit, and understanding the factors that influence this choice may be helpful in developing strategies to promote increased transit

ridership. The role of attitudes and neighborhood design are of particular interest. Using data from a 2003 survey on travel behavior, this paper explores the factors associated with transit use in eight Northern California neighborhoods. Multivariate analyses for transit use and frequent transit use showed that attitudes play a more significant role than neighborhood design. A case study of the Mountain View neighborhood illustrated the importance of direct transit service to work in explaining commute mode choice. If planners hope to increase transit ridership, then they must consider the attitudes of travelers about transit in addition to neighborhood design and the quality of transit service.

Handy, S. L., Mokhtarian, P. L & Cao, X. (2006).*Does the Built Environment Influence Vehicle Type Choice? Evidence from Northern California*. Washington, DC: Transportation Research Board.

It is evident that compact development can lower auto ownership, reduce trip lengths, and increase the uses of alternative modes. Recently, several studies found that suburban development is associated with the unbalanced choice of light duty trucks (LDTs). These studies have not shed much light, however, on the underlying direction of causality- whether neighborhood designs as opposed to attitudes towards vehicle choice more strongly influence individuals' decisions on vehicle type choice. The available evidence thus leaves unanswered questions: if policies require more compact, mixed-use development, will more people choose to drive passenger automobiles? And if so, what are the implications for air quality? Using a survey of 1682 respondents in Northern California, this study applied correlational analyses and multinomial logit model (MNL) to investigate the causal link from the built environment to vehicle type choice. The results from correlational analyses showed that the built environment has a strong association with vehicle type choice. Specifically, traditional designs (exhibiting mixed land uses and/or high accessibility) are correlated with the choice of passenger automobiles, while suburban designs (including large yards and off-street parking) are associated with the choice of LDTs- especially minivans and pickup trucks. The MNL model suggests that attitudinal factors play an important role, and that the built environment impacts vehicle type choice after controlling for attitudinal and demographic variables. Therefore, this study provides supportive evidence for the argument that smart growth strategies have the potential to reduce the choice of LDTs, thereby reducing emissions. However, the mediating effects of attitudinal factors suggest that ignoring the role of attitudes will lead to an overestimation of the influences of smart growth strategies on vehicle type choice and thus emissions.

Handy, S., Cao, X., & Mokhtarian, P. L. (2005). Correlation or Causality between the Built Environment and Travel Behavior? Evidence from Northern California. *Transportation Research Part D, 10,* 427–444.

Previous studies have shown that, all else being equal, residents of neighborhoods with higher levels of density, land-use mix, transit accessibility, and pedestrian friendliness drive less than residents of neighborhoods with lower levels of these characteristics. However, these studies have not established the underlying direction of causality--in particular, whether neighborhood design influences travel behavior or whether travel preferences influence the choice of neighborhood. This leaves a key question largely unanswered: if cities use land use policies to bring residents closer to destinations and provide viable alternatives to driving, will people drive less and thereby reduce emissions? The present study uses quasi-longitudinal design to investigate the relationship between neighborhood characteristics and travel behavior while taking into account the role of travel preferences and neighborhood preferences in explaining this relationship. A multivariate analysis of cross-sectional data shows that differences in travel behavior between suburban and traditional neighborhoods are largely explained by attitudes and that the effect of the built environment mostly disappears when attitudes and sociodemographic factors are accounted for. However, a quasi-longitudinal analysis of changes in travel behavior and changes in the built environment shows significant associations, even when attitudes have been accounted for, providing support for a causal relationship. Although these results provide some evidence that land-use policies designed to put residents closer to destinations and provide them with alternatives to driving will actually lead to less driving, the analyses presented here are not definitive, nor do they clarify the nature of the causal relationship. Directions for future research are discussed.

Handy, S.L. & Clifton, K.J. (2001). Local Shopping as a Strategy for Reducing Automobile Travel, *Transportation 28*, 317-346.

Suburban development in the United States is widely criticized for its contribution to automobile dependence and its consequences. This paper explores how residents in existing neighborhoods make use of the local shopping opportunities currently available to them and, based on that, evaluates the possibility that providing local shopping opportunities could help reduce automobile dependence. Two sets of questions were addressed, using both quantitative and qualitative evidence for six neighborhoods in Austin, Texas. The questions were: 1) To what degree do residents choose local shopping over more distant opportunities, and why?; and 2) To what degree do residents choose to walk rather than drive to the local shopping center and why? The results and conclusions are provided.

Hendricks, Sara, J., et. Al., (2005) *Impacts of Transit Oriented Development on Public Transportation Ridership*. Center for Urban Transportation Research, University of South Florida, Tampa, FL.
The purpose of Phase I of this study was to develop a research design to better establish the relationship between transit oriented development (TOD) and travel mode share. The initial hypothesis that good quality transit combined with good quality TOD would succeed in shifting travelers from single-occupant vehicle travel to transit was found to be an oversimplification. Good quality transit service is necessary and good quality TOD is likely helpful and important to shifting mode share but not sufficient. Other necessary factors include supporting elements of the larger urban spatial structure, disincentives to driving alone, favorable marketability of TOD for non-transportation reasons, and incentives to use transit. Research literature suggests that elements of urban form are perhaps not the most important determinants of travel behavior, specifically mode choice, number of trips taken and length of trips. However, urban form does appear to exert some kind of influence, and for that reason, it is worthwhile to further specify the relationship to ascertain how policy initiatives relating to TOD can support the goal to balance mode share in the direction of greater transit use. To better define the elements of TOD that shape travel behavior, this study describes a research design for the development of a panel survey, using recently developed cell phone technology, to track the same individuals and households over time. Using a pre-test post-test design, the survey data collected for a region in Florida would be a sound investment for improved travel forecasting, modeling and other uses.

*Hensher D A (ed.) Travel Behaviour Research. The Leading Edge*. Elsevier, 2001.
Abstract for Chapter entitled “Interfaces between Location, Land Use and Travel Decisions”: This paper focuses on some current trends and new research issues. Connection between land use and various traffic measures, the effects of urban development on mode shares, the connection between location choice and choice of car ownership and total vehicle miles traveled, and the influence of accessibility on residential location, modelling the joint choice of location and travel pattern represent some of the areas discussed.

*Hess, P M and Moudon, A V and Logsdon, M G.* Measuring Land Use Patterns for Transportation Research*. Transportation Research Board, 2001.*
Density and land use mix are focused on as the two primary variables for characterization of land use in transportation research. As commonly constructed, these variables do not capture well actual development patterns on the ground, thus obscuring a potentially strong relationship between land use and transportation behavior. To overcome these limitations, parcel-level data and geographic information system software were used to identify and measure attributes of land use. These data are at a level of resolution that closely corresponds to the spatial distribution of development patterns. A method for location of concentrations of medium- to high-density housing and commercial development in suburban areas identified in previous research is described. The method includes the use of metrics derived from landscape ecology to model these development patterns and, specifically, their shapes and their functional and spatial mixes.

Jin, X and Beimborn, E and Greenwald, M. *Impacts Of Accessibility, Connectivity and Mode Captivity on Transit Choice*. University of Wisconsin, Milwaukee; Federal Transit Administration, 2004.
It is the objective of this report to examine the way that transit service factors such as accessibility and connectivity can be used to define mode captivity, and seek to incorporate these factors in mode split models to see whether segmentation between the captivity groups can lead to better methods of forecasting. The data for this study come from the Portland, Oregon 1994 Household Activity and

Travel Diary Survey, the Regional Land Information System for the Portland Area, the U.S. Environmental Protection Agency Fuel Economy Database, and the U.S. Department of Energy. Individual trip data were segmented into transit captive, auto captive and choice users based on information about private vehicle availability, transit connectivity and distance from a transit stop. Traditional transit mode split models are compared to models that segment users into choice and captive groups. The results suggest that traditional models underestimate the variation in mode choice for captive users, while overestimating the attractiveness of transit for choice users. Incorporating mode captivity factors can improve the accuracy of the logit model, either by segmenting the market or by employing the factors as independent variables. The explanatory power of the models will largely increase when captivity conditions are used in the equation to predict transit use. Multinomial regression model was developed to predict captivity. Transit captives could be predicted by auto ownership patterns. Auto captivity is dependent on trip origin-destination locations and transit service frequency and coverage besides the factor of auto ownership. Additionally, among choice transit users, differences in travel times between automobile and transit modes does little to influence mode selection; while automobile ownership, and out-of-vehicle time are the most important factors in terms of influencing mode choice.

Johansson, Maria. *Childhood Influences on Adult Travel Mode Choice*. International Conference of Traffic and Transport Psychology, Elsevier, 2005.

A large number of European children are today chauffeured by car to school and leisure activities. This increased car use for children's trips affects the local and global environment negatively. Parents have a crucial role in the decision of travel mode choice. In a study of 357 Swedish children ages 8-11 years, the parents had decided upon travel mode for 73% of the children's trips. Research in the related fields of driving behavior shows that the parents' attitudes and behavior may transfer to young drivers, partly through modeling of parental life style and driving style. This paper discusses the impact of parental attitudes and mode choice in childhood on adult choice of travel mode. Travel mode choice is based on a large number of factors, including more psychological variables such as values and norms, attitudes, and habits, but also physical environment, more practical matters such as time and weather conditions, and health aspect play a role in individual travel patterns.

Kain, J F. *A Tale of Two Cities: Relationships between Urban Form, Car Ownership and Use and Implications for Public Policy. In: Recent Developments in Transport Economics*. Edward Elgar Publishing Incorporated, 2003.

This paper is concerned with the interrelationships among household incomes, urban development patterns, car ownership, trip-making and modal choice and with appropriate policy responses to what are still perceived as growing problems associated with rapid increases in car ownership and use. In this research two separate papers were used as references, the paper also reviews research on car ownership and use by other authors.

Khattak, A. J. et. al. (2005, February). *Traditional Neighborhood Development Trip Generation Study*. North Carolina Department of Transportation.

Since the beginning of the new urbanist movement, alternately referred to as Traditional Neighborhood Developments (TNDs), planners and architects have touted their neighborhood and community designs for reducing residents' reliance on the automobile by creating compact, mixed use, and pedestrian friendly developments. However, researchers have not explicitly examined how travel behavior and traffic impacts differ in a tightly controlled comparison of conventional and traditional developments. Additionally, current forecasting models and trip generation procedures need to be tested for their applicability to these new developments. This report aims to fill that void by studying a matched-pair of neighborhoods: One conventional and one traditional. The neighborhoods are located in the Chapel Hill/Carrboro area of North Carolina. Traffic counts were taken at all entrances and exits to the developments, and a detailed behavioral survey of the residents was conducted in the two neighborhoods during 2003. The results show that households in Southern Village, the TND, make about the same amount of total trips, but significantly fewer automobile trips, fewer external trips and they travel fewer miles, when compared to households in the conventional neighborhoods. However, this reduction of trips in a suburban environment does little to decrease delay at "over-designed" intersections along major highways. Finally, ITE trip generation methods and

rates are acceptable for predicting the trip generation of the study neighborhoods. The implications of these results are discussed in the report.

Kim, Tae-Gyu and Goulias, Konstadinos G and Burbidge M.A., Shaunna K.. *Travel Behavior Comparisons of Active Living and Inactive Living Lifestyles*. Transportation Research Board, 2006.
The past century?s radical change and innovation in transportation technology and concomitant increase in options for our travel modes moves us away from walking to an almost total extinction of modes that require physical exercise. This is accompanied by a modern American city design that requires the use of an automobile with urban sprawl creating distant destinations that alter older methods of travel and make active forms of transportation almost impossible. However, many more reasons exist that motivate people to choose physically inactive modes as our research shows here. Using a two-day activity diary collected in Centre County, Pennsylvania, we identify which factors influence active versus inactive mode choice. In this analysis, the paper examines the correlations between trip purpose and travel mode and between age and travel mode, and perform an analysis of travel distances to determine what the distance threshold is for active modes. In addition, a latent class cluster analysis establishes a profile for both physically active as well as inactive travelers and their correlation with person and household characteristics. Key findings include that trips made using active modes are significantly different than trips made by inactive modes and persons with active transportation lifestyles are significantly different than persons with inactive lifestyles. This raises the following issue: policies designed for and motivated by persons with active lifestyles risk to fail if they do not succeed in meeting the needs for everyday life of those with inactive lifestyles.

Kitamura, R., Akiyama, T., Tamamoto, T., & Golob, T. F. (2001). *Accessibility in a Metropolis: Toward A Better Understanding of Land Use and Travel.* Washington, DC: Transportation Research Board, TRR 1780, 64-75.
An attempt was made to determine how accessibility affects aspects of long-term and short-term travel behavior. The accessibility indices that were used represent the ease with which opportunities for engagement in activities can be reached from a geographical zone in an urban area. The behavioral aspects examined include engagement in activities, automobile ownership and use, and travel patterns as represented by the number of trips, number of trip chains, and total travel time expenditure. Data from the Kyoto-Osaka-Kobe metropolitan area of Japan and the southern California coast are used to examine the following conjectures: time availability is more closely associated with engagement in activities than accessibility; accessibility no longer affects automobile ownership or use in the metropolises of industrialized countries where motorization has matured; and given automobile ownership and use, travel patterns are conditionally independent of accessibility.

Knapp, G. & Song, Y. (2005). The Transportation – Land Use Policy Connection. Chapter 5 In D. Levinson and K. Krizek (Eds.), *Access to Destinations*. London: Elsevier.
The paper explores the transportation-land use policy connection. More specifically, it considers the question, can land use policy be used to alter transportation behavior? The answer is of some importance. If the answer is yes, then there is hope that land use policies can be designed and implemented that will bring some relief to the congestion and complex transportation problems that are facing US metropolitan areas. This is the underlying assumption behind most smart growth policy reforms. If the answer is no, then land use policy may still be important, but is not likely to play an important role in resolving transportation issues. The paper then offers a schematic that identifies necessary conditions for land use policy to play a role in addressing transportation issues. Specifically, the paper argues that for land use policy to play an effective role, three conditions must hold. First, land use must be able to alter transportation behavior; secondly, transportation infrastructure must not fully determine land use; and thirdly, the condition on which the authors consider most extensively, land use policy must significantly and constructively affect land use. After presenting the schematic, the paper considers the evidence on each of these conditions. Based on the review of the evidence, the paper concludes that land use policy can play an effective role in transportation issues, but that the role is likely to be small, often counter productive, and most effective at the neighborhood scale.

Krizek, K. J. (2000). A Pre-test/Post-test Strategy for Researching Neighborhood-scale Urban Form and Travel Behavior. *Transportation Research Record, 1722,* 48-55.

Communities are increasingly looking to land use planning strategies based on a less auto-dependent urban form to reduce the need for travel, especially drive-alone travel. In recent years, several studies have attempted to test the impact urban form has on travel behavior to determine if such designs are warranted. The results of these studies are mixed because of several shortcomings. Some shortcomings can be attributed to data availability; others are a product of the techniques used to characterize urban form or travel. Still other shortcomings are embedded in the strategies employed, using cross-sectional travel data and correlating travel outcomes with urban form. The line of research is being extended, aimed at isolating the influence of urban form on travel behavior; a new research strategy is presented using longitudinal travel data in concert with detailed measures of travel behavior and urban form. Data sources from the Puget Sound are described and a research strategy is presented that permits a pretest-posttest analysis of households' travel behavior before and after they changed residential location. Early results show few changes in household travel behavior after a move, suggesting that attitudes toward travel are firmly entrenched and postmove travel provides little insight into how changes in urban form affect travel. Although a pretest-posttest makes valiant strides in shedding new light on the matter, the complex phenomenon being addressed requires myriad approaches. More comprehensive research techniques and even research approaches based on different traditions are much needed to better understand how urban form and travel interact.

Krizek, K. J. (2003). Planning, Household Travel, & Household Lifestyles. In K.G. Goulias (Ed.) *Transportation Systems Planning: Methods and Applications*. Boca Raton, FL: CRC Press, 6.1-6.42.

Concerns about urban sprawl, growth, and traffic are now among the most important issues facing the U.S. Consequently, transport planners are looking to a variety of solutions. One prescription that has recently received increased scrutiny is the joining of transportation planning with land use planning as a means of influencing travel. This chapter aims to provide an overview of past and current research on this subject and describes the relevance of related land use--transportation policy.

Krizek, K. J. (2003). Neighborhood Services, Trip Purpose, & Tour-Based Travel. *Transportation*, 30, 387-410.

This paper investigates the relationship between accessible land use patterns and household travel behavior. A framework is described that provides a more behavior-based understanding of household travel than traditional trip-based travel analysis, which often does not consider the linked nature of most travel. The framework highlights travel tours, the sequence of trips that begin and end at home, as the basic unit of analysis. A typology of travel tours is offered to account for different travel purpose. This typology helps in the understanding of tours relative to the range of services typically offered in accessible neighborhoods. The relationship between tour type and neighborhood access is empirically analyzed using detailed travel data from the Central Puget Sound region of Seattle, Washington. Findings indicate that households living in areas with higher levels of neighborhood access tend to leave home more often, but make fewer stops per tour. These households make more simple tours for work and maintenance (i.e., personal, appointment and shopping) trip purposes, but there is no difference in the frequency of other types of tours. While they travel shorter distances for maintenance-type errands, a large portion of their maintenance travel is still pursued outside the neighborhood. These results suggest that living close to services has a surprisingly small savings effect on vehicle miles of travel.

Krizek, K. J. (2003). Operationalizing Neighborhood Accessibility for Land Use-Travel Behavior Research and Regional Modeling. *Journal of Planning Education and Research, 22*(3), 270-287.

Many land use–transportation planning proposals aim to create neighborhoods with higher levels of neighborhood accessibility (NA). This article focuses on how such features are operationalized for purposes of research and/or regional modeling. The first section reviews specific variables classified by three basic tenets of NA: density, land use framework, and streets/design. The second section describes challenges in measuring NA to provide a better understanding of how such challenges shape research efforts and applications. The final section creates an NA index that is applied to the Central Puget Sound metropolitan area. The index uses detailed measures of density, land use mix, and street patterns and makes at least five contributions for urban form research.

Krizek, K. J. (2003, Spring). Residential Relocation and Changes in Urban Travel: Does Neighborhood-Scale Urban Form Matter? *Journal of the American Planning Association*, *69*(3), 265-281.
This paper presents an empirical study of the relationship between neighborhood-scale urban form and travel behavior. The focus is on households that relocate within the Central Puget Sound region (Washington) to determine if they change their travel behavior when they move from a given neighborhood type to a different one. Regression models are used to predict change in travel behavior as a function of change in neighborhood accessibility, controlling for changes in life cycle, regional accessibility, and workplace accessibility. A special feature of the study is that it analyzes the travel behavior of the same households in a longitudinal manner in concert with detailed urban form measures. Findings suggest that households change travel behaviors when exposed to differing urban forms. In particular, relocating to areas with higher neighborhood accessibility decreases vehicle miles traveled.

Krizek, K. J. (2005). *Household Lifestyles and Their Relationship to Land-Use and Transportation Planning*. Minneapolis: Humphrey Institute of Public Affairs.
This article examines the links between different dimensions of household decision making, including the types of ravel residents engage in, the types of activities they tend to pursue, and factors affecting their choice of neighborhood. The author analyzes these and other factors in a synergistic manner to come up with a concept called household lifestyles. The author compiled a large data set from a variety of sources, including the Travel Behavior Inventory Home Interview Survey (conducted in the seven county Twin Cities, Minnesota area). The author discusses the implications of the household lifestyles concept for urban planning initiatives, many of which are focusing on making walking in cities easier, more attractive, and more available. The author contends that recognizing how household decisions form together into different groups helps one better understand how relevant decisions related to one another, the market segments of different populations, and subsequently the merits of various policy scenarios.

Krizek, K. J. (2005). Perspectives on Accessibility and Travel. In D. Levinson and K. J. Krizek (Eds.), *Access to Destinations* (pp. 109-130). London: Elsevier.
This paper describes how urban form, whether it is compact, multi-nodal, or sprawling, impacts they type and cost of transportation systems needed to serve residents of a metropolitan area. On the other hand, the type and location of major transportation facilities greatly influences urban form. Almost a half of century's worth of study on the link between the two provides a solid foundation to understand some inherent interactions between land use and transportation. These interactions manifest themselves in two forms: (1) the influence of urban form on transportation systems, travel demand, and urban travel behavior; and (2) the influence of transportation systems and transportation investments on metropolitan urban form. The two phenomena share a common heritage; however each asks different questions, and they often relate to different scales of analysis. This paper attempts to describe the issues that emanate from the former question—that is, what do we know abut the manner in which land use patterns affect household travel. In doing so, the paper discusses how the relationship between urban form and transportation has historically been conceptualized and also summarizes some of the existing research. The paper then turns to describing how the history relates to new and pressing research questions that provide the impetus for studying more in depth matters related to accessibility.

Krizek, K. J. (2006). *Lifestyles, Residential Location Decisions, & Pedestrian and Transit Activity*. Washington, DC: Transportation Research Board, TRR 1981, 171-178.
The idea of using land use patterns to influence people's behavior is popular in urban planning circles these days. Activity-based travel modeling has begun to make significant progress toward a more behavioral framework for simulating household travel behavior and understanding, in particular, pedestrian activity. A significant challenge remains in the need to address the interaction of pedestrian use with longer-term household choices of neighborhood choice, other activities, and overall travel. The choices often depend on one another and jointly define the lifestyle of an individual. This paper refines a framework to analyze household choices relating to three dimensions of lifestyle: travel patterns (including pedestrian activity), activity participation, and neighborhood characteristics. Cluster analysis on data from the Twin Cities metropolitan region in Minnesota

uncovers seven classifications of lifestyle. These clusters demonstrate empirically how decisions about residential location reinforce and affect daily decisions related to travel patterns, pedestrian and transit use, and activity participation. The final section comments on the applicability of these lifestyle clusters for land use–transportation planning.

Krizek, K. J. (2006, Summer). Two Approaches to Valuing Some of Bicycle Facilities' Presumed Benefits. *Journal of the American Planning Association*, *72*(3), 309-320.
This study uses two different approaches to value the benefits of bicycle lanes and trails. In the first approach, an adaptive stated preference survey is used to measure how much travel time individuals are willing to spend to obtain particular features of on- and off-street bicycle facilities. These findings indicate that bicycle commuters in Minneapolis and St. Paul prefer bicycle lanes on existing streets over off-street bicycle trails, and also prefer them over streets that have no on-street parking but lack designated bicycle lanes. In the second approach, home sales data was used to investigate the effect of bicycle trail proximity on home value. Findings indicate that the three types of bicycle facilities (lanes on existing streets, facilities separated from roadways by curbs or landscaping, and facilities within open spaces) were valued differently. Results also show that bicycle facilities have different values in the city than they do in the suburbs and that bicycle facilities are not always considered an amenity. Although proximity to most bicycle facilities did not significantly affect home values in city neighborhoods, bicycle facilities significantly reduced home value in suburban locations. Home values in both city and suburban neighborhoods were most reduced by proximity to roadside trails.

Krizek, K. J, & P. J. Johnson (2006, Winter). Proximity to Trails and Retail: Effects on Urban Cycling and Walking, *Journal of the American Planning Association*, *72*(1), 33-42.
In this study, multivariate modeling techniques are used to estimate the effect of household proximity to retail and bicycle facilities on the odds of walking and cycling. The authors analyzed these relationships employing detailed geographic information systems data and individual-level travel diary data from Minneapolis and St. Paul, Minnesota. Findings indicate that distances to retail and bicycle facilities are statistically significant predictors of choosing active modes of transport and close distances. However, the relationships do not appear to be linear. One needs to live very close for such facilities to have a statistically significant effect on cycling or walking. The results also underscore that walking and bicycling are fringe modes and represent rare travel behaviors. The overall findings cast doubt on the potential of community design to induce physical activity.

Krizek, K. J & Roland, R. (2005). What is at the End of the Road? Understanding Discontinuities of On-Street Bicycle Lanes in Urban Settings. *Transportation Research Part D, 10*(1), 55-68.
Although demarcating on-street bicycle facilities is an important strategy in encouraging bicycle safety and bicycle travel, few studies have focused on instances where separate on-street bicycle facilities end. This paper seeks to determine bicyclists' comfort levels when encountering discontinuities and examines the strength of explanatory factors affecting their severity. The authors identify 30 discontinuities of on-street bicycle lanes in Minneapolis, Minnesota, and collect primary data measuring their physical attributes and cyclists' perceptions of the level of comfort while cycling through each. Using multivariate analysis, the findings suggest that discontinuities ending on the left side of the street, with increased distance of crossing intersections, having parking after the discontinuities, and wider width of the curb lanes are statistical elements that contribute to higher levels of discomfort. The findings from this study draw attention to the worst discontinuities. The study also offers a taxonomy for transportation planners to better understand

Krizek, K. J & Waddell, P. (2002). Analysis of Lifestyles Choices: Neighborhood Type, Travel Patterns, & Activity Participation. *Transportation Research Record*, *1807*, 119-128.
Activity-based travel modeling has begun to make significant progress toward a more behavioral framework for simulating household travel behavior. A significant challenge remains in the need to address the interaction of daily activity and travel patterns with longer-term household choices of vehicle ownership, residential location, and employment location. The choices often depend on one another and jointly define the lifestyle of the household. These choices are likely to evolve over the course of the life cycle as households are formed; as children are born, raised, and ultimately depart to form their own households; and as retirement and old age change patterns of residence, work, and travel. A framework is developed for analyzing household choices relating to three dimensions of

lifestyle: travel patterns (including vehicle ownership), activity participation, and residential location (neighborhood type). With cluster analysis on data from the Puget Sound Transportation Panel, nine classifications of lifestyle are uncovered. These clusters demonstrate empirically how decisions of residential location reinforce and affect daily decisions related to travel patterns and activity participation. The applicability of these lifestyle clusters for land use transportation planning is discussed.

Krizek, K. J., El-Geneidy, A., & Thompson, K. (2007). A Detailed Analysis of How an Urban Trail System Affects Cyclists' Travel. Transportation Research Board 86th Annual Meeting.
Transportation specialists, urban planners, and public health officials are steadfast in encouraging active modes of transportation over the past few decades. Conventional thinking, however, suggests that providing infrastructure for cycling and walking in the form of off-street trails is critically important. An outstanding question in the literature, however, is how such facilities relate to larger issues of travel behavior. This research describes a highly detailed analysis of use along a primarily off-street trail in Minneapolis, Minnesota, USA. The core questions addressed in this investigation aim to understand relationships between: (1) the propensity of trail use and distance from residence, and (2) how far out of their way do trail users appear to travel for the benefit of using the trail. The data source used in the analysis for this research was collected as a human intercept survey along a section of an off-street facility. Trail users seem to travel significantly out of their way (14.6 percent longer) in order to include a trail facility on their route. The effect is heightened on weekends and on longer trips. The results and analysis in this study may be used to guide planning, maintenance, and programming of Hennepin County's trail system in upcoming years. The distance decay and shortest path versus taken path analysis offer insight into how far bicyclists are willing to travel in order to use a trail facility. This information can be used to guide the spacing of new trails to maximize levels of use.

Lin, J & Long, L. *What Neighborhood Are You In? Empirical Findings on Relationships Between Residential Location, Lifestyle, & Travel*. Washington, DC: Transportation Research Board, 2006.
This paper describes how neighborhood type and lifestyle are important factors influencing household and individual travel behavior. This paper presents a statistical clustering approach coupled with Geographic Information System (GIS) spatial analysis to characterize neighborhood lifestyles using sixty-four features extracted from the Census Transportation Planning Package (CTPP) 2000 data. The resulting ten clusters reveal different neighborhood lifestyles in terms of individual or household socio-economics, demographics, and land use. Travel characteristics of each cluster using the 2001 National Household Travel Survey (NHTS) travel data suggest five factors influencing household travel, socio-economic status, residential location and land use, household life cycle, activity type, and ethnics. This study has important implications to the travel demand modeling and transportation planning community. Statistical classification coupled with GIS spatial tools provides a means to associate a household with its neighborhood environment. Each neighborhood type is distinctively defined and reasonably homogenous in terms of socio-economic and travel characteristics. This not only improves travel demand prediction capability but is also more desirable when transferring travel information between geographic zones. The empirical findings from NHTS also shed lights to transportation decisions that involve the transportation-land use relationship, increasing mobility and accessibility for city low incomes, and coping with changes of travel due to demographic change.

Lund, H. M., & Cervero, R., & Wilson, R. W. (2004). *Travel Characteristics of Transit-Oriented-Development in California.* Pomona, CA: California State University.
This study presents a 2003 measurement of travel behavior in transit- oriented developments (TODs) in California. It builds upon previous studies conducted in the early 1990 by adding new residential, office and hotel sites to address new questions, and includes TODs built ore recently. It examines a range of potential rail users, such as residents, office workers, hotel employees and patrons, and retail patrons. It presents results of surveys conducted along each of California's major urban rail systems. The study also collects detailed data on site and neighborhood factors that potentially affect the likelihood of using transit and models those factors as they relate to individual and project-level travel behaviors. The study is intended to assess the success of TODs in enhancing transit ridership and to identify TOD design and policy features that contribute to success.

Lund, H. (2006). Reasons for Living in a Transit-Oriented Development and Associated Transit Use. *Journal of the American Planning Association*, *72*(3), 357-366.
Transit-oriented development (TOD) near rail stations offers the hope of increasing both transit use and the number and range of housing opportunities. This paper reports the results of a survey of households who moved to TODs in the San Francisco Bay Area, Los Angeles, or San Diego within the last five years. Findings showed a wide range of motivations, with type or quality of housing, cost of housing and quality of neighborhood being the most frequently cited factors. Only about one-third of respondents reported access to transit as one of their top three reasons for choosing to live in a TOD. Those who reported that their choice of residence location was motivated in part by access to transit were 13 to 40 times more likely to use transit than those who did not. TOD residents do appear to use transit at a relatively high rate compared to the general population.

Maat, Kees and Timmermans, Harry J P. *Influence of Land Use on Tour Complexity: A Dutch Case*. Transportation Research Board, 2006.
It is assumed that in new urban designs and compact cities, average travel distances tend to be shorter and more activities are linked in chains. As there is relatively little empirical evidence about the relationship between chain behavior and land use, especially from Europe, a study was done to obtain a better understanding of the influence of chains (referred to as tours) to test the hypothesis that compact urban forms reduce travel. The results indicate that higher densities lead not only to greater activity and greater tour demand but also to more complex tours. Although greater tour frequencies reduce mean tour distance, daily distance traveled increases. Moreover, complex tours have an encouraging effect on both tour distance and daily distance traveled. This confirms the hypothesis and previous evidence that more frequent tours and more stops per tour in high-density areas lead to more travel.

Matsumura, H and Kawata, H. *Socio-Economic Characteristics, Land Use and Travel Patterns*. American Society of Civil Engineers, 2000.
Osaka City is located in the central part of Japan. The city is bordered to the west by Osaka Bay and to the south and north by the Yamato and Kanzaki Rivers, respectively. The city serves as a business center for the western portion of the country, as well as Osaka metropolitan area, which includes Kyoto, Kobe, and Nara, covering an area within a radius of 50 km from the city. Osaka encompasses an area of approximately 220 square km, including newly reclaimed off shore land. This paper discusses the effects of socioeconomic aspects, land use factors, and locations of major facilities on travel patterns in Osaka City, and also provides an overview of its transportation network and infrastructure and public transit systems.

McCormack, E., Rutherford, G. S., & Wilkinson, M. G. (2001). *Travel Impacts of Mixed Land Use Neighborhoods in Seattle, Washington*. Washington, DC: Transportation Research Board.
In response to suburban transportation problems, developers and planners have suggested that mixing land uses can reduce automobile dependency by making more goods and services available within walking, biking, and short driving distances. This view has resulted in a neotraditional planning movement that promotes neighborhoods designed with traditional characteristics including a mix of land uses. However, few studies have empirically explored the transportation implications for these neighborhoods. This issue is addressed by using a travel diary collected in three greater Seattle area neighborhoods characterized by neotraditional neighborhood elements including mixed land use. These data were compared with those collected in an identical diary from individuals throughout the region. It was found that residents of the mixed land use study neighborhoods in Seattle traveled 28% fewer kilometers (miles) than residents in adjacent areas and up to 120% fewer kilometers than residents in suburban areas. This trend of lower travel distances held across different socioeconomic characteristics. However, the differences in travel distances among the areas were not seen when travel time was considered. The daily travel time was about 90 min/person (including walking), regardless of where that person lived and that person's socioeconomic status. One implication of this finding is that if a neotraditional neighborhood development does make shopping and other chores less time-consuming, there may simply be more time in the travel budget for additional regional travel. This suggests that travel from the neotraditional neighborhoods needs to be examined in a regional context.

Mesa, J L and Baron, F F. *Socioeconomic Characteristics, Land Use And Travel Patterns: A Profile Of Miami-Dade County*. American Society of Civil Engineers, 2000.
Miami-Dade County is a large metropolitan area located near the tip of the Florida peninsula along its southeast coast. This area has experienced significant growth in recent years. This paper provides an overview of the historical development, land use and urban form, transportation networks, urban transit networks, airport and sea port, and population and demographics of the greater Miami-Dade County metropolitan area. The paper concludes with remarks on the current and future transportation preferences of County residents, which continue to show a fondness for auto travel as the primary transportation mode.

Newman, P. and Kenworthy, J. (2006). Urban Design to Reduce Automobile Dependence, *Opolis: An International Journal of Suburban and Metropolitan Studies*, 2(1), Article 3.
A major goal of urban design, especially in centers, is to reduce automobile dependence in order to address issues of viability and sustainability. Long-term data from cities around the world appear to show that there is a fundamental threshold of urban intensity (residents and jobs) of around 35 per hectare1 where automobile dependence is significantly reduced. This article seeks to determine a theoretical base for what the data show. It suggests that below the threshold intensity of urban activity, the physical constraints of distance and time enforce car use as the norm. The basis of these physical constraints is outlined and the link between density and access to services that provide amenity is established, including the service levels of public transport. A design technique for viability of centers is suggested as well as how a city can restructure itself to overcome automobile dependence.

Noreen C. McDonald, Travel and the social environment: Evidence from Alameda County, California. Transportation Research Part D: Transport and Environment. Volume 12, Issue 1, January 2007, Pages 53-63
The relationship between travel and the environment has been the subject of much study but the focus has mainly been on the physical and built environment. This ignores a large body of research in sociology showing that social processes are spatially embedded and affect individual behavior. This analysis asks whether the neighborhood social environment – in addition to the built environment – influences children's decision to walk to school in Alameda County, California. The results show that social factors, particularly neighborhood cohesion, do influence the decision to walk particularly when children face trips of less than 1.6 km. These findings provide initial evidence for transportation analysts to broaden their definition of the environment to include social factors.

Nunes da Silva, F. & de Abreu e Silva, J. (2003). To What Extent Does Urban Density Influence the Modal Split? The Lisbon Metropolitan Area Case Study. In L.J. Sucharov and C.A. Brebbia (Eds.) U*rban Transport IX*. Ashurt, UK: WIT Press.
The relationship between urban density and car use appears to have a growing importance as urban areas experience sprawl and tend to be more diffuse. With this in mind, this paper examines a recent mobility survey conducted in the Lisbon Metropolitan Area (LMA). The main aim was to determine the extent to which density influences the modal split in identical situations of public transport supply and population demographics. Vehicle weight was considered the dependent variable, with 2 approaches developed: 1) one that considers the urban density, for each specific socioeconomic level, as the only explicative variable; and 2) one that uses a multivariate regression analysis using density, availability, family income, public transport supply, and public transit comfort levels as explicative variables of car use. Results obtained from both methods are compared and discussed in order to identify the real weight of density as an explicative variable of car use in LMA.

Polzin, S. (2004). The Relationship between Land Use, Urban Form and Vehicle Miles of Travel. Tampa: Center for Urban Transportation Research, University of South Florida.
This white paper provides a review of the literature and a synthesis of findings regarding the relationship between land use and urban form and the vehicle miles of travel by persons. The paper begins with a conceptual outline of the transportation-land use relationship. It synthesizes a broad review of the literature and explores various aspects of the state of knowledge regarding the transportation-land use relationship. Various perspectives and motivations, analytical methods, variables for measurement, and urban scale focuses are discussed in the paper. An overview of

research findings categorized by geographic scale ranging from site level, to neighborhood level, to urban area level is provided. Policy Implications are provided and a concluding section offers observations on how the available knowledge can be used in decision-making.

Racca, D. P & Ratledge, E. (2003). *Factors that Affect and/or Can Alter Mode Choice*. Prepared for Delaware Transportation Institute and Delaware Department of Transportation.

This project uses data about individuals, their characteristics, the trips they make, and the costs and benefits of travel modes, to identify factors that can be used in models for travel mode choice. In Delaware, for the past eight years, the Delaware Department of Transportation (DelDOT) has sponsored the DelDOT Household Survey. Approximately 200 people of the age of 16 or older are called on the telephone and asked to describe the trips they have taken in the previous day. Trip origins and destinations are geo-coded to a small geographic unit (modified grid), and information is obtained for trip time, purpose, incidental stops, travel preferences, demographic data, vehicle occupancy, travel mode, and other information. This is a wealth of information very suited to the modeling goals of this project. The modeling of transit use was a focus in this project. Automobiles offer large advantages over transit in convenience, flexibility, and travel time. A particular level of service of transit is necessary to have people choose to use transit over a car when they have the choice. Factors that reflect the transit level of service are necessary in any model, and level of service factors certainly significantly influence mode choice. A review of the literature indicates many types of service factors that have been used in mode choice models. Level of service is often very difficult to quantify. This project employed road network models and optimum routing algorithms as available in geographical information systems to estimate travel times and service factors for trips taken by individuals. This project is the first part in a two part modeling effort. Once mode choice is modeled at the individual and trip level, a study will be done on how travel mode split can be modeled at the smaller levels of geography like traffic zones for use in route planning and travel demand forecasting.

Rodriguez, D A and Joo, J. *The Relationship between Non-Motorized Mode Choice and the Local Physical Environment*. Transportation Research Part D, 9, 2: 151-173, Elsevier, 2004.

This study uses multinomial choice models to examine the relationship between travel mode choice and attributes of the local physical environment such as residential density, walking and cycling paths, topography, and sidewalk availability. The relationship between mode choice and the objectively measured environmental attributes are illustrated using data for student and staff commuters at the University of North Carolina in Chapel Hill. The modeling approach is used in conjunction with traditional modal measures such as travel time, access time, and cost. Results suggest that the four attributes of the local physical environment jointly make significant marginal contributions in explaining travel mode choice. In particular, the estimates reveal that local topography and sidewalk availability are significantly associated with the attractiveness of bicycling and walking modes, respectively. Point elasticities are provided. The findings highlight the importance of considering non-motorized options in travel mode choice studies and incorporating measures of the local physical environment to refine calculations of generalized costs.

Salon, Deborah. *Cars and the City? A Model of the Determinants of Auto Ownership and Use For Commuting in New York City with Endogenous Choice of Residential Location*. Transportation Research Board, 2006.

Cities around the world are trying out a multitude of transportation policy and investment alternatives with the aim of reducing car-induced externalities. However, without a solid understanding of how people make their transportation and residential location choices, it is hard to tell which of these policies and investments are really doing the job and which are wasting precious city resources. The focus of this paper is on the determinants of the choice of car ownership within the context of the related decisions of residential neighborhood and commute mode. Treating all three of these choices as endogenous, I estimate a discrete choice model using survey data from 1997-98 collected in the New York metropolitan area. New York City is unique within the United States in that it has unusually low auto ownership rates. Identifying both the relative contributions of and the potential synergies between the factors that cause New Yorkers to be content to live without cars is important, and could lead to policy solutions for cities aiming to reduce their car dependence. Results indicate that in New York City, the most effective way to reduce car use for commuting is to decrease commute time for

non-car modes. To reduce car ownership, the most important policy-sensitive variable appears to be population density. But effectiveness is not necessarily the same as cost-effectiveness. To use these results to inform policy, they must be combined with cost information about competing policy alternatives to identify the most cost-effective options.

Scheiner, Joachim. *Housing Mobility and Travel Behaviour: A Process-Oriented Approach to Spatial Mobility: Evidence from a New Research Field in Germany*. Elsevier, 2006.

In recent years, some effort has been made to understand the location changes in the life course underlying travel demand in Germany. Such studies have presented travel behavior and long-term housing mobility as intertwined decision flows within the life course. This perspective calls for new methods, such as comparisons of travel behavior before and after relocation, or comparisons between different ?relocation types?. A number of studies have been conducted on this new perspective. Although there are certain methodological problems arising, notable progress has already been made towards a more precise understanding of travel demand. This includes the investigation of the use of transport modes as well as traveled distances and activity spaces. This paper provides an overview of these studies. Theoretical groundwork, empirically validated aspects, and deficits and blind spots of research are discussed.

Schneider, Robert James and Rodriguez, Daniel A. and Young, Hannah M.. *Easy-to-Compute Index for Identifying Built Environments That Support Walking*. Transportation Research Board, 2006.

The variety and spatial co-variation of built environment attributes associated with non-automobile travel have resulted in the estimation of composite scores or indices summarizing these attributes. This paper builds on prior practical and research applications of these environmental scores or indices by proposing and testing a built environment index (BEI) calculated at the traffic analysis zone and that relies predominantly on widely available data. By computing the BEI using three different analytical methods used in prior research (principal components analysis, cluster analysis and an ANOVA method), we examine whether the indices created are comparable. Results suggest a high correlation between the BEI calculated with these methods, with principal components analysis appearing slightly superior to the two other methods. We also compare the BEI with Portland's Pedestrian Environment Factor (PEF) and find a high degree of consistency between the two. Because the BEI can be readily calculated, does not rely on field survey data and has high validity, we recommend it as an overview tool to classify built environments in their ability to support walking. When appropriate, additional disaggregate data can be used to examine the urban neighborhood with higher spatial resolution.

Schwanen, T. & Mokhtarian, P. L. (2005). *What Affects Commute Mode Choice: Neighborhood Physical Structure or Preferences toward Neighborhoods?* London: Elsevier.

The academic literature on the impact of urban form on travel behavior has increasingly recognized that residential location choice and travel choices may be interconnected. We contribute to the understanding of this interrelation by studying to what extent commute mode choice differs by residential neighborhood and by neighborhood type dissonance—the mismatch between a commuter s current neighborhood type and her preferences regarding physical attributes of the residential neighborhood. Using data from the San Francisco Bay Area, we find that neighborhood type dissonance is statistically significantly associated with commute mode choice: dissonant urban residents are more likely to commute by private vehicle than consonant urbanites but not quite as likely as true suburbanites. However, differences between neighborhoods tend to be larger than between consonant and dissonant residents within a neighborhood. Physical neighborhood structure thus appears to have an autonomous impact on commute mode choice. The analysis also shows that the impact of neighborhood type dissonance interacts with that of commuters' beliefs about automobile use, suggesting that these are to be reckoned with when studying the joint choices of residential location and commute mode..

Shay, E. & Khattak, A. J. (2005). *Automobile Ownership and Use in Neotraditional and Conventional Neighborhoods*. Washington, DC: Transportation Research Board. TRR 1902, 18-25.

Although the commonly accepted link between automobile ownership and automobile use has inspired some municipalities to experiment with neighborhood design in an attempt to influence both automobile ownership and travel behavior, the underlying relationship between neighborhood design

and automobile ownership is still unclear. Evidence suggests that automobile ownership is tightly linked to income and household size and is less responsive to urban design. This research uses data from a matched pair of neighborhoods, one conventional and one neotraditional, to consider the relationship between neighborhood design and automobile ownership and the relationship between these factors and automobile use. Statistically significant differences were found for automobile ownership in the two neighborhoods. In addition, there were clear differences in automobile use: residents of neotraditional developments made fewer automobile trips, traveled fewer miles in their vehicles, and spent less time driving. This has implications for planning strategies that may help reduce automobile trips and miles separately from changes in automobile ownership.

Shay, E., Fan, Y., Rodriguez, D. A., & Khattak, A. J. (2006). *Drive or Walk? Utilitarian Trips Within a Neotraditional Neighborhood*. Washington, DC: Transportation Research Board. TRR 1985, 1-15.

An extensive body of literature has developed on the relationship between the physical environment and travel behavior. Although many studies have found that neotraditional neighborhood development supports nonautomobile travel by providing good street connectivity, pedestrian and cycling facilities, and internal destinations, questions remain about the travel behavior of individuals within such neighborhoods. This study uses travel diaries to examine utilitarian trip-making behavior within a neotraditional neighborhood and compares total trips with mode-specific (i.e., walk and drive) trips. Negative binomial regression is used to examine the effect of a set of independent variables, including personal and household characteristics, select attitudinal factors, and distance from residences to the commercial center. It is found that within the neotraditional neighborhood, walk trips drop off quickly with increasing distance to destinations, whereas drive trips increase. The analysis demonstrates the importance of short distances for within-neighborhood travel and the merit in considering trips separately for walk and drive modes to avoid obscuring important factors associated with trip making.

Soltani, A. & Allan, A. (2006, September). Analyzing the Impacts of Microscale Urban Attributes on Travel: Evidence from Suburban Adelaide, Australia. *Journal of Urban Planning and Development*, *132*(3), 132-137.

Metropolitan Adelaide in Australia is dominated by low-density suburbs with an extensive and large road supply, which brings with it car-dependent lifestyles that are ultimately unsustainable in the longer term. Changes are needed to make a city such as Adelaide less car-dependent toward a city that relies on more sustainable transport modes for its day to day urban travel needs. This paper presents the results from a comparative study of travel patterns among residents of four suburban residential areas in metropolitan Adelaide. Using existing datasets together with inventory data of urban environment characteristics from original fieldwork, this paper examines to what extent there are associations between various attributes of a particular urban location as they relate to travel behavior and household socio-economics. The findings derived from multinomial logit models show that suburban development pattern and design attributes can potentially create shifts in transport modal split suggesting that microscale urban features should be given more attention in transport policy making.

Srinivasan, S. (2001). *Quantifying Spatial Characteristics for Travel Behavior Models*. Washington, DC: Transportation Research Board.

Land use initiatives represent a potentially effective tool for coping with the kinds of mobility patterns that North American cities face in the 1990s and in the coming century. As fine-grained data about land use and travel activity become available, they provide the opportunity to improve the understanding of the linkage between land use and transportation. The neighborhood characteristics that could affect travel behavior on the nonwork tour are examined in detail. Neighborhood characteristics include land use, network, and accessibility-related characteristics quantified through the use of a geographic information system. Ultimately, such measures could be used in conjunction with detailed surveys of travel behavior to specify, calibrate, and use models of modal choice and trip type that are more sensitive to the fine-grained spatial structure of neighborhoods and transportation corridors in metropolitan areas. Microlevel data for the Boston metropolitan area, together with a 1991 activity survey of approximately 10,000 residents, provide a rich empirical basis for experimenting with relevant neighborhood measures and for simulating their effects on travel behavior. Spatial

characteristics affect travel behavior even on the relatively (spatially) restricted nonwork tour and could be potentially useful for transportation planning.

Srinivasan, S. (2005). *Influence of Residential Location on Travel Behavior of Women in Chennai, India*. Washington, DC: Transportation Research Board.

The visible impact of urban transportation is in access to employment. However, transportation also affects access to other services such as shopping and social service facilities. Past research in Chennai, a large city in India, indicates that the relocation of the very poor in peripheral informal settlements severely affects their accessibility to jobs and services because of the commuting distances involved when employment opportunities continue to remain highly centralized. In this study an attempt was made to understand the influence of relative location within the city on travel behavior by using a sample of 116 low-income households from a variety of locations in Chennai. In particular, the travel behavior of women as affected by location was assessed. Models estimated to determine the influence of location characteristics on household travel behavior indicate that availability of transportation choices did affect the travel behavior of women even after differences in their life-cycle stage are accounted for. Recently, Chennai has been investing heavily in rail for public transportation without estimating current travel demand by spatial location within the city. The implications of this policy for integrated land use and transportation planning are especially pertinent in this context.

Steiner, R. L., Wright, S. A., & Paul, J. B. (2000). *Travel in New Urbanist and Traditional Communities: A Case Study of Downtown Orlando, Volume I: Final Report and Appendix A*. Tallahassee: Florida Department of Transportation.

The claim that traditional urban forms reduce the level of automobile dependence, especially for trips to and from work and during the peak travel time, is examined in this research. While it would be ideal to consider New Urbanist communities, it is widely accepted that they have not reached the maturity necessary to allow them to be considered. Thus, this research considers the travel of residents who choose to live in traditional neighborhoods that afford the use of a range of transportation options. Downtown Orlando, including its adjacent neighborhoods, has been chosen as the location of this research because it appears to have the characteristics that encourage non-automobile travel. The downtown is built on a grid street network. Transit service is widely available. Many jobs are available in downtown Orlando. The city of Orlando's policies support a high quality of life in neighborhoods and encourage traditional neighborhood development in existing neighborhoods and the new development within the Naval Training Center Plan and Southeast Sector Plan. Many people who live in downtown Orlando have an income high enough to allow them the full options of transportation services, including automobile ownership. Thus, this research characterizes the travel of medium to high-income residents of the neighborhoods of downtown Orlando. The results of this research will begin to clarify whether the Florida Department of Transportation, as a matter of policy, should support such development, and, if so, what other policies should be in place to make it more effective.

TRB, Transit Cooperative Research Program (TCRP) Report 95: Chapter 15 – Land Use and Site Design, 2003

While transportation is a long-acknowledged factor in shaping cities and determining land development potential, as the result of enhanced accessibility, the reciprocal impact of land use decisions on transportation outcomes has only gradually achieved recognition. It is these reciprocal impacts, of interest in treating land use or site design options as “transportation” strategies that provide the impetus for this chapter. Presented here is information on the relationships between land use/site design and travel behavior, drawn primarily from research studies that have attempted to measure and explain the effects. TCRP Report 95: Chapter 15, Land Use and Site Design will be of interest to transit, transportation, and land use planning practitioners; educators and researchers; and professionals across a broad spectrum of transportation and planning agencies, MPOs, and local, state, and federal government agencies.

Waling, H. *Socio-Economic Land Use and Travel Patterns in Amsterdam*. American Society of Civil Engineers, 2000.

The number of inhabitants in Amsterdam is influenced by various developments such as the transition of population to the suburbs and the effects of foreign immigration on growth and prosperity. Many demographic factors, such as the age and number of inhabitants, play a part in the social and

economic structure of the city. This paper deals with land use and the various social and economic characteristics of the occupants of Amsterdam and their travel patterns, and how these factors impact on public transportation.

WEINER, E and Gorham, R. *LAND USE--TRANSPORTATION INTERACTIONS: WORKSHOP REPORT. IN: IN PERPETUAL MOTION: TRAVEL BEHAVIOR RESEARCH OPPORTUNITIES AND APPLICATION CHALLENGES*. Elsevier, 2002.

This report describes a workshop that focused on methodologies and needs of researchers looking into whether a causal link exists between human settlement patterns in urbanized regions and travel behavior. Workshop participants generally agreed that the interactions between these phenomena are quite complicated, and that land-use policy alone will be insufficient in reducing car dependency. The central issue then becomes, how can researchers isolate the effects of land-use if it is apparent that land-use alone is not sufficient to influence travel behavior. This problem is discussed in detail.

Zegras, P.C. (2004). The influence of land use on travel behavior: Empirical evidence from Santiago de Chile. *83rd Annual Meeting of the Transportation Research Board*, Washington, DC.

Zegras, P.C. (2006). *The Built Environment and Motor Vehicle Ownership and Use: Evidence from Santiago de Chile*. Paper #07-3034. Washington, DC: Transportation Research Board.

This paper examines the role that the built environment – both micro-scale "neighborhood" design characteristics and meso-scale relative location – play in influencing motor vehicle ownership and use in a rapidly motorizing, developing city context: Santiago de Chile. The paper first answers the question: what role, if any, do factors such as dwelling unit density, land use mix, street design, and proximity to public transportation stations play in determining household motor vehicle ownership? The question is answered by specification and estimation of a multinomial logit model of vehicle choice. The paper then turns to a second-stage question: what role does the built environment play on household automobile use? This question will be answered by specification and estimation of an ordinary least squares regression model, predicting the amount of total household automobile use (measured by distances traveled on a given day). The two models are explicitly linked via the use of the "selectivity bias correction factor." The implications of the findings for planning and design are discussed.

Zhang, M. (2005). *Intercity Variations in the Relationship Between Urban Form and Automobile Dependence: Disaggregate Analyses of Boston, Massachusetts; Portland, Oregon; and Houston, Texas*. TRR 1902. Washington, DC: Transportation Research Board.

This study was motivated by the need for more empirical research on the urban form-travel connection. A two-tiered travel effect is expected from strengthening the urban form-travel connection: the enhancement of access to choices and a shift in travel mode choice from driving to nondriving. Existing studies have focused primarily on the second-tier effect but have largely omitted the first. This study attempted to fill that gap. Through joint-logit modeling of choice set formation and travel mode choice in three cities: Boston, Massachusetts; Portland, Oregon; and Houston, Texas; the study measured the degree of automobile dependence in the three cities. It also estimated elasticities of automobile dependence and of driving probabilities with respect to land use densification, transit access improvement, and control of motorization. There were large variations in the levels of automobile dependence and their elasticity estimates among the three cities. Public policies aimed at reducing automobile dependence should be formulated and evaluated based not just on the final outcome of modal split but also on the provision of travel options to travelers. As cities differ in their existing urban forms, currently available transportation services, and prevailing preferences of travel, it is important to recognize that the same set of policy strategies implemented in different cities is unlikely to generate the same level of effects in reducing automobile dependence.