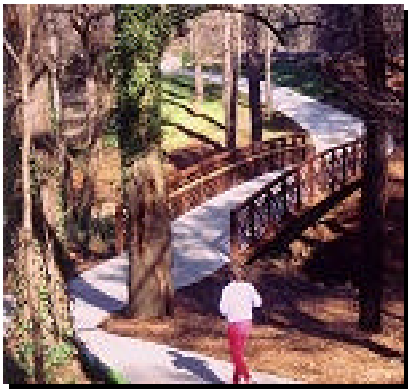


How Land Use and Transportation Systems Impact Public Health:

An Annotated Bibliography



ACES: Active Community Environments Initiative Working Paper # 2

How Land Use and Transportation Systems Impact Public Health:

*An Annotated Bibliography*¹

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ACES: Active Community Environments Initiative Working Paper #2

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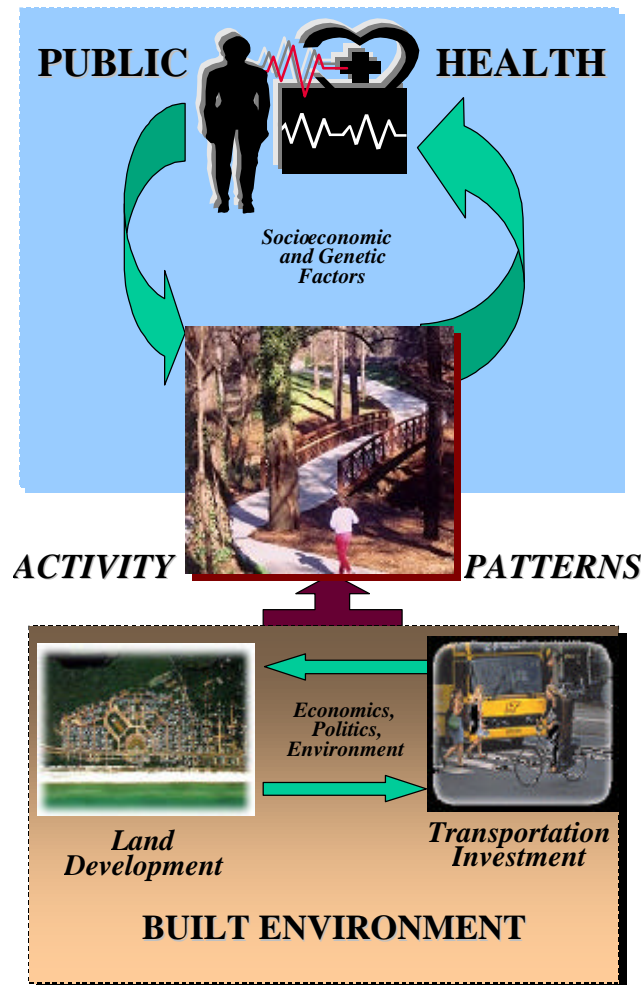
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Article Review Structure:

This annotated bibliography is structured around the relationships between the built environment, activity patterns, and public health.

Figure 1

Relationships Between Urban Form, Activity Patterns, and Public Health



Each document is reviewed in accordance with the following four questions:

1. What was the impetus for the study/article?
2. What methods and data sources were used (i.e. empirical, descriptive)?
3. What were the findings and how were they used?
4. How does this study contribute to a synthesis of the literature and implications for further research?

This bibliography was conducted as a way to begin synthesizing the literature on the effects of urban form and transportation system investments on physical activity, especially on walking and bicycling. This bibliography and the subsequent synthesis of the literature will be used to guide development of empirical research in the area. As additional literature is reviewed, and as additional research findings are obtained the bibliography will be updated. Because literature databases such as Medline and Psychological abstracts do not exist for this literature, the bibliography is based on iterative reviews of sources that provided initial materials, meta-searches through Galelelo and on systematic review of sources suggested by transportation and urban design practitioners and researchers. Key words used in the searches are listed below.

We hope this bibliography will be useful to public health professionals and others that are beginning to explore how population wide levels of moderate intensity physical activity such as walking and bicycling can be enhanced by changes in the environment and in the policies that influence urban design and transportation infrastructure.

Keywords:

Physical activity, urban form, urban design, barriers, pedestrian, walking, fitness, exercise, health promotion, active living, sedentary lifestyle, traffic safety

II. Transportation – Travel and Safety Statistics

Antonakos, C. 1995. Nonmotor Travel in the 1990 Nationwide Personal Transportation Survey. *Transportation Research Record 1502: 75-82.*

1. This study examines demographic and trip data for individuals surveyed under the 1990 Nationwide Personal Transportation Survey (NPTS).
2. Personal characteristics and travel behaviors of individuals classified by the NPTS as being either non-motorists, motorists, or mixed were analyzed using descriptive and inferential (chi-squared) statistics.
3. Non-motorists were more likely to be under 21 or over 65 years old, were more likely to live in the central city, and were less likely to be employed, be licensed drivers, or live in a household with a vehicle. Non-motorized trips were shorter in distance and less likely to be work-related than motorized trips.
4. This study provides background data on the demographic and travel behavior differences between motorists and non-motorists.

Daisa, J., Jones, M., and A. Wachtel. 1996. Children, Traffic, and Safety: Responding to the School Commute. *Institute of Transportation Engineers 66th Annual Meeting: 1996 Compendium of Technical Papers: 163-6.*

1. This paper reviews efforts by the city of Palo Alto, California to understand safety problems related to the home-to-school commute.
2. This paper reviewed the four major tasks of the city's study: problem definition and review, field data collection, definition and listing of potential improvements and safety enhancements, and creation of a final report.
3. The study traced the development of traffic engineering solutions, educational solutions, marketing/community awareness solutions, and on-site school circulation solutions.
4. This paper provides a useful summary of one city's attempt to address safety problems involved in children bicycling and walking to school.

Durkin, M., Davidson, L., Kuhn, L., O'Connor, P., and B. Barlow. 1994. Low-Income Neighborhoods and the Risk of Severe Pediatric Injury: A Small-Area Analysis. *American Journal of Public Health* 84(4): 587-92.

1. The purpose of this study was to investigate the relationship between socioeconomic disadvantage and the incidence of severe childhood injury.
2. Small-area analysis was used to examine socioeconomic risk factors for pediatric injury resulting in hospitalization or death in northern Manhattan, New York, NY, during a nine-year period (1983-1991). Residents of two health center districts in this part of Manhattan are disadvantaged (according to major socioeconomic indicators) relative to the rest of New York City. Data was collected on all injuries to residents younger than age 17 that resulted in hospitalization or death, drawn from two study hospitals. Patient records were matched to census tract of residence. Socioeconomic indicators (e.g., poverty, single parents, non-high school graduates, unemployed men, mothers not employed) for each census tract in the study area were derived from the 1990 census. Statistical analyses were performed to assess the impact of low-income neighborhood as a risk factor for severe childhood injury.
3. The average annual incidence of all causes of severe pediatric injury was 72.5 per 10,000 children. Census tract proportions of low-income households, single parent families, non-high school graduates, and unemployment were significant predictors of risk for both unintentional and intentional injury. Among the socioeconomic factors considered, low income was the single most important predictor of all injuries; other socioeconomic variables were not independent contributors once income was included in the model. The mean annual incidence of motor vehicle injuries (per 10,000 population) was 12.6; pedestrian injuries were 7.8 per 10,000, while passenger injuries were only 1.1 per 10,000. The authors speculate that higher pedestrian injuries in poorer neighborhoods may be the result of both greater traffic volumes and fewer places for children to play other than on streets.
4. This study provides quantitative evidence that children from poorer neighborhoods are at greater risk of injury and death from motor-vehicle related causes, in particular as pedestrians. The study's goal, however, is to address the relationship between all causes of severe childhood injury and socioeconomic variables.

Environmental Working Group and Surface Transportation Policy Project. 1997. *Mean Streets: Pedestrian safety and reform of the nation's transportation law.* Washington, D.C.

1. This report, a collaborative product of the Surface Transportation Policy Project and the Environmental Working Group, was created in response to the reauthorization of ISTEA in 1997. The focus of the paper is to argue for safer roads and streets through diversified investment of transportation expenditures. It seeks to end the imbalance of



spending policy in order to save lives, prevent injury, and give local people greater say in making their neighborhoods more livable.

2. This article cited numerous safety and spending statistics regarding the walking and driving. These included the Federal Highway Administration, the General Accounting Office, the National Safety Council, and the U.S. Department of Transportation. These statistics highlighted the lack of attention given to pedestrian safety and access both theoretically and financially. The billions of dollars spent each year are actually making the roads less safe for pedestrians. The Highway Capacity Manual – one of the industry bibles – defines a pedestrian as a traffic “flow interruption.”
3. The results of the article can be synthesized into four major recommendations for improving pedestrian safety and access; first, it recommends that Congress continue to preserve and strengthen ISTEA’s current safety programs to better protect pedestrians. Second, establish a national goal of increasing pedestrian safety by doubling the percentage of total trips made by biking and walking while reducing fatalities by 10%. Third, ensure that road-building projects don’t increase hazards for pedestrians. And fourth, collect more accurate and detailed data on pedestrians and walking.
4. A number of statistics compiled in “Mean Streets” would support the notion that urban form directly effects public health. The statistics presented in “Mean Streets” focus not on increasing physical activity as a way to improve public health but rather on the safety of pedestrians. For instance, the authors state that 55% of all pedestrian deaths by automobile occur on neighborhood streets. Currently, most streets are being designed as speedways, inaccessible and unsafe for pedestrians and bicyclists. “Mean Streets” also presents a telling ranking of the U.S. most dangerous communities in which to walk. The list clearly shows that the most dangerous metropolitan areas for walkers are the newer, sprawling, southern and western communities and the safest communities are found in the denser northeast where walking activity is high.

“Mean Streets” is on the right track but stops short of recommending that communities such as suburban cul-de-sacs are dangerous. Instead, the authors recommend the use of traffic calming and separation design techniques combined with public education and law enforcement in order to make roads safer for pedestrians citing Seattle and Portland having successful programs.

Federal Highway Administration. 1997. *Our Nation’s Travel: 1995 NPTS Early Results Report*. Washington, D.C.: U.S. Department of Transportation.



1. This report summarizes the results of the 1995 NPTS.
2. This report provides descriptive statistics from the NPTS, including trend data from the 1969 through 1995 NPTS. A large number of tables and charts are provided.
3. The report finds, among other things: commute trips are in the minority of all trips, with family and personal business being the most frequent type of trip; 90% of all trips are by single occupancy vehicle (SOV); there are 56 million walk trips and 9 million bike trips per day in the U.S.
4. This study is useful in providing basic statistics about personal travel behavior in the United States. Raw data is not provided in this summary, however.

Federal Highway Administration. 1994. *The National Bicycling and Walking Study. Case Study Number 1: Reasons Why Bicycling and Walking are and are not Being Used More Extensively as Travel Modes.* Washington, D.C.: U.S. Department of Transportation.

1. This report assesses the current levels of bicycling and walking for utilitarian and recreational purposes and assesses the potential for increased amounts of walking and bicycling. Most of the study focuses on bicycling.
2. This study is a summary of knowledge on walking and bicycling, and utilizes material and data from previously published sources. Chapter two, however, is an analysis of bicycling data gathered in 20 U.S. cities. The study summarizes the individual choice to walk or bicycle, examines aggregate levels of bicycling and walking in selected cities, and attempts to determine the environmental and policy factors that inhibit bicycle riding.
3. For individual factors, age is the most significant demographic variable influencing bicycling levels, especially utilitarian bicycling. Bicycle trips are taken for recreation or for errands, with commuting much less prevalent. The main incentives motivating bicycle usage are exercise and enjoyment, with some evidence that environmental concerns are a factor. The main disincentives are traffic safety, lack of viable routes, and weather. For bicycle commuting, distance to the work place, traffic safety, and the absence of shower and parking facilities at work are the main disincentives. The level of bicycling across the 20 cities examined varied substantially. The most significant variable appeared to be the dominating presence of a university. Commute distance and primary bicycling facilities also appeared to be connected with high levels of bicycle commuting. Cities with higher levels of bicycle commuting have on average 70% more bikeways per roadway mile and six times more bike lanes per arterial mile. It is also speculated that high density levels without safe bicycling facilities may not induce more cycling (due to greater traffic volumes). Cities with higher levels of

bicycling also tend to be laid out in grids. Climate does not seem to be correlated with interest in bicycling except as a seasonal and daily variable in the decision to bicycle.

4. This study provides a good summary of the state of knowledge into the individual variables that impact the decision to bicycle. It also provides some original data regarding the relationship between urban form, transportation systems, and bicycling. However, the research design does not employ rigorous statistical testing.

Federal Highway Administration. 1994. *The National Bicycling and Walking Study: Transportation Choices for a Changing America. Final Report. Publication No. FHWA-PD-94-023. Washington, D.C.: U.S. Department of Transportation.*

1. This report was prepared as part of the National Bicycling and Walking Study mandated by the 1991 US Department of Transportation Appropriations Act. It presents a plan of action for activities at the federal, state, and local levels for meeting two goals: to double the current percentage of total trips made by bicycling and walking, and to reduce by ten percent the number of bicyclists and pedestrians killed or injured in traffic crashes. This report was put together by a working group within the U.S. Department of Transportation that included representatives from a variety of federal agencies.
2. This is an issue-oriented report that advocates a particular set of policy changes. It asserts the need for more walking and bicycling and fewer injuries to these groups of street users, and outlines an action plan for achieving its goals. It draws upon numerous other recent studies of biking and walking, including the 24 case study reports completed for the FHWA on different aspects of bicycling and walking. What data is used is provided by secondary sources.
3. The report reviews current (as of 1994) levels of bicycling and walking, outlines the health benefits of increased walking and bicycling, and examines the potential for increasing physical activity levels. It also outlines a federal action plan consisting of nine action items, including the integration of bicyclist and pedestrian needs into transportation planning and procedures at the federal level, providing funding for a pedestrian- and bicycle-friendly infrastructure, conducting promotion and awareness activities, and providing education and training for planning and engineering professionals that encourages routine consideration of the needs of pedestrians and bicyclists. These goals can successfully be met if coordinated and committed effort is put forth at every level of government. Support for walking and bicycling must be institutionalized and supported by the private sector as well.
4. This study outlines one course of action for the federal government, highlighting what this level of governance can and cannot do to improve non-motorized transportation options in the U.S. It provides little in the way of new data, but it does provide a synthesis of research regarding who walks and bikes, how much, where, and for what

reasons. It discusses barriers and benefits of non-motorized transportation. It specifically mentions the health benefits and some of the social costs that could be avoided through increased participation in non-motorized transportation.

Go for Green/EnviroNics. 1998. *1998 National Survey on Active Transportation: Summary Report*. Ottawa, Canada.

1. The major objective of this study was to establish a baseline of participation in active transportation (walking and cycling) among adults and school-aged children in Canada.
2. The 1998 survey of 1,501 adults aged 18 and older was conducted by telephone in each of the ten Canadian provinces. The national sample included a subsample of 429 adults with children 18 or less, still attending school. The survey research was also followed up by a series of focus groups on cycling in Vancouver, Toronto, Montreal, and Halifax.
3. The survey results showed that 85% of Canadians reported walking for leisure, while 58% reported walking “at least sometimes” to a routine destination. Overall, 43% walk more than half the time to at least one destination. The average distance traveled is 3.2 kilometers each way. The principal barriers to walking were, in order, distance, time, weather, inconvenience, and health/disability. About one in two respondents reported cycling for leisure or recreation purposes, but the figure was much lower for cycling to routine destinations. The average cycling distance traveled was 5.6 kilometers each way. The principal barriers to cycling were, in order, distance, weather, time, traffic/safety, and inconvenience.
4. This study presents survey data of walkers and bicyclists in the Canadian context.

Highway Safety Research Center. 1994. *A Compendium of Available Bicycle and Pedestrian Trip Generation Data in the United States. A Supplement to the National Bicycling and Walking Study*. Prepared for the Federal Highway Administration. Chapel Hill, NC: University of North Carolina.

1. The purpose of this study was to gather information to aid in the determination of trip generation rates for various bicycling and walking facilities, such as signed and marked bicycle lanes, wide curb lanes, multi-use paths, and sidewalks. This report also covers the state of research into bicycle and pedestrian levels of service (LOS).
2. This report utilized a selected literature review and contacts with individuals in communities across the U.S. known to have active bicycle and pedestrian programs. A diversity of data sources such communities generated statistics regarding facilities

usage. As a result, this report contains an array of usage data from different communities and different types of facilities, with different collection methods.

3. Most of the sources of bicyclist and pedestrian trip generation counts were for specific geographic areas. Most were also for bicycles. For bicycles, a variety of methods were used, including manual counts and automatic detectors. For newly-installed bicycle facilities (e.g., bike lanes), few before-and-after data collection efforts were found. Findings for pedestrian facilities were similar. Few data collection efforts attempted to assess how many trips were generated by facilities, or about how many pedestrian trips would not have been made had a facility not been in place. A chapter on LOS defines the concept and covers early attempts at its operationalization.
4. This report is helpful in illustrating the state of research (as of 1994) into bicycle and pedestrian trip generation. Despite the attempts by many localities to devise measures, the report makes clear that available data is inadequate to determine to what degree the creation of pedestrian and bicycle facilities increases walking and bicycling.

Hillman, M., Adams, J., and J. Whitelegg. 1990. *One False Move: A Study of Children's Independent Mobility*. London: PSI Publishing.

1. This book addresses trends in the travel patterns and levels of personal autonomy of children aged 7-11 and 11-15 in Germany and Britain. The goal was to assess the degree to which parents grant "licenses" to their children, defined as parental authorizations for their children to travel by themselves. It partially replicates a study in England in 1971.
2. Surveys were carried out in schools in England and Germany in similar types of urban areas. The goal was to devise a set of indicators of the licenses granted by parents. The central aim was not to assess the physical danger of traffic, such as average traffic volume or speed over a given stretch of road; rather, the authors aimed to increase the body of data regarding people's responses to traffic danger.
3. Over the period 1971-90, English children became significantly less independent. In 1971 nearly half of the seven year olds crossed roads unaccompanied, but by 1990 only a fifth did so. More than half of German children of this age did so in 1990. By 11 years of age this difference between German and English children had disappeared. The main reason given by English parents for restricting their younger schoolchildren from coming home alone after school was traffic danger (more than 40% cited this reason). The authors claim that children's loss of independent mobility by bicycle has been as pronounced as that for walking. They also speculate that children's play territory has been reduced as roads have become progressively more dangerous. The authors conclude that large increases in traffic volumes in the United Kingdom since 1971 have led to an increase in parents' concern about the risks to their children.

4. This study is one of a few to address the question of how childhood mobility has been impacted by increases in traffic volume. The method employed is novel: rather than attempting to correlate increases in traffic volume to decreases in observed travel (non-motorized) behavior by children, the authors instead attempt to gather data on how parents view the walking and bicycling environments in which their children operate, and whether these environments have led to the withdrawal of mobility licenses from their children.

Hu, P. and J. Young. 1999. *Summary of Travel Trends: 1995 Nationwide Personal Transportation Survey*. Prepared for U.S. Department of Transportation, Federal Highway Administration. Knoxville, TN: Oak Ridge National Laboratory.

1. This paper provides transportation trend data from the 1995 NPTS and from previous versions of the NPTS.
2. This study reviews the 1995 NPTS goals and methodology and utilizes descriptive data to summarize travel trends from the 1969, 1977, 1983, 1990, and 1995 NPTS.
3. Trend data for household travel, personal travel, private vehicle travel, vehicle availability and utilization, commute travel patterns, and travel behavior of sub-populations are provided.
4. This study provides a quick review of travel patterns over time, including motorized travel and vehicle availability. Nonmotorized travel is not covered.

Murakami, E. and J. Young. 1997. *Daily Travel by Persons with Low Income*. In *Proceedings from the Nationwide Personal Transportation Survey Symposium*. Prepared by MultiConsultant Associates, Inc. for the Office of Highway Policy Information, Federal Highway Administration, U.S. Department of Transportation. Washington, D.C.

1. This study analyzes travel patterns by income in the 1995 NPTS. The intent is to generate a better understanding of low-income travel behavior.
2. Descriptive statistics are utilized to break down NPTS travel and demographic data, for example income versus household characteristics, income by vehicle ownership, and income by mode use.
3. The study finds that persons in households with low incomes walk nearly twice as much as people in other income groups, primarily due to the fact that low-income persons are much less likely to own a vehicle. This latter finding does not imply that vehicles are unavailable to low-income persons. While motorized trips still make up

the majority of all trips, these trips are much more likely to be made in a vehicle owned by someone else, such as a friend or relative.

4. This study is useful in that it disaggregates the 1995 NPTS data by income level. It supports the hypothesis that wealth is inversely related to walking for utilitarian trips.

Niemeier, D., and G.S. Rutherford. 1994. *1990 NPTS Report Series: Travel Mode Special Report*. Prepared for U.S. Department of Transportation, Federal Highway Administration. Washington, D.C.

1. The purpose of this study is to present the results of an evaluation of travel characteristics associated with households and individuals making non-motorized trips. The study used data from the 1990 NPTS.
2. This study analyzes 1990 NPTS data using descriptive statistics. Households making non-motorized trips in the NPTS data are compared to households making no such trips, using a host of demographic and urban form characteristics as explanatory variables. A large number of charts and tables are provided.
3. The report finds that households making only motorized trips consistently make fewer trips than non-motorized households, controlling for demographic and urban form characteristics. Households making non-motorized trips also average fewer daily VMT, suggesting that non-motorized travel may replace some motorized trips. The authors also found that walk trips but not bike trips increase with density.
4. This study provides a basic analysis of the characteristics of households that made one or more non-motorized trip during the taking of the 1990 NPTS. Using national-level data, it provides support to the notion that urban form variables are correlated with walk and bike trips.

Organisation for Economic Co-operation and Development (OECD). 1998. *Safety of Vulnerable Road Users*. DSTI/DOT/RTR/RS7(98)1/FINAL. Paris: OECD, Directorate for Science, Technology, and Industry, Scientific Expert Group on the Safety of Vulnerable Road Users.

1. This report presents a review of the current safety situation of vulnerable road users in OECD member countries. Vulnerable road users are defined as those unprotected by an outside shield while in traffic, namely, pedestrians and cyclists. The bulk of this report focuses on the most vulnerable of this population: the elderly, children, and disabled persons. The study was begun in 1995 and defines the main safety problems faced by vulnerable road users.
2. This is a lengthy report that attempts to summarize the state of research into vulnerable road users in OECD member countries. It provides an overview of their mobility patterns and accident characteristics based on available travel surveys and national statistics. Safety measures are also addressed. Comparative and trend statistics are provided.
3. An analysis of the content of laws and regulations in OECD member states revealed that pedestrians are generally considered to be external elements, needing protection, but at the same time disturbing traffic; while national legislation shows concern about the special vulnerability of children, the elderly, and the disabled, established traffic rules seldom refer to these road user groups. The physical environment of vulnerable road users is heterogeneous: on inter-urban roads, priority remains with the car; in many old and dense city centers, pedestrians and cyclists have some priority over the car; in many residential areas, traffic calming techniques have shifted the balance toward pedestrians and cyclists. However, comprehensive networks – with appropriate continuity and safety – for pedestrians and cyclists is only starting to be introduced as part of the transport planning process. Few cities have designed specific facilities to promote mobility of the disabled. The elderly often have to cope with road crossing lights or conditions meant for more alert pedestrians or cyclists. Children are very much at risk in most areas of a city, with the exception of some calmed residential streets. Regarding accident statistics, the elderly account for the larger share of pedestrian and cyclist fatalities in European countries and Japan, while children tend to get involved in accidents on minor roads (consistent with their exposure patterns). Car/pedestrian accidents are a function of vehicle speeds, lack of communication between road users, differences in expectations between the different road users, and perceptual problems experienced by the children and elderly. Policy recommendations are provided.
4. This report provides a lengthy discussion and analysis of the problems faced by the elderly, children, and the disabled in negotiating traffic on foot or by bicycle. Particularly valuable are chapters two (characteristics and environment), three (mobility), four (safety), and seven (infrastructural safety measures).

Pisarski, A. 1996. *Commuting in America II: The Second National Report on Commuting Patterns and Trends*. Landsdowne, VA: ENO Transportation Foundation, Inc.

1. This report is a follow-up to a 1987 report on commuting behavior in the U.S. The 1996 report updates earlier findings regarding trends in commuter travel.
2. This study utilized data from the 1960 through 1990 Census. Trend data on labor-force, vehicle ownership, modal share, travel time, and housing are gathered and analyzed.
3. Findings were mixed. While trend data suggest that there has been a marked increase in the number of workers and in the number of automobiles used for commuting, both of these trends seem to be leveling off. Increases in suburb-to-suburb commuting, however, show no signs of slowing. Average travel times for commuters did not increase substantially between 1980 and 1990.
4. This report provides a useful summary of trends in commuter behavior in the U.S., illustrating the dominance of the automobile, for example, in commuting. There is some data on the demographics of commuters who walk or bicycle to work.

Pless, B., Verreault, R., Arsenault, L., Frappier, J., and J. Stulginska. 1987. The Epidemiology of Road Accidents in Children. *American Journal of Public Health* 77(3): 358-60.

1. This study reports the incidence of traffic injuries to children in Montreal in 1981. It contrasts characteristics of the mild and severely injured. It also compares the usefulness of police reports with information based on hospital records.
2. The population studied consisted of all children living in Montreal in 1981 as estimated from that year's census. A monitoring system was established in eight general hospitals and two children's emergency departments to identify all children seen as a result of a motor vehicle accident (MVA). Injuries were coded as mild or severe. Data from police reports provided information about the circumstances of the event. Accident rates were calculated for areas where postal codes matched census tracts and classified by socioeconomic strata (SES), based on a child-poverty index.
3. The accident rate to children in Montreal during this year was 33.4 per 10,000. 57% of the injuries were to pedestrians, 24.5% were to passengers, and 18.4% were to bicyclists. Nearly 20% were hospitalized and 1.2% died. One-third were considered by the authors to have severe injuries with highest rate of severe injuries found among pedestrians. Pedestrian and bicycle (but not passenger) injuries in low-income areas were four to nine times greater than those in more affluent areas.
4. This study provides medical data to substantiate the claim that motor vehicles are a significant source of child injuries and deaths. Moreover, the data shows that motor

vehicles are particularly dangerous to children who walk and bicycle. Finally, it supports the proposition that children are at greater risk to traffic in low-income areas.

Waller, A., Barker, S., and A. Szocka. 1989. Childhood Injury Deaths: National Analysis and Geographic Variations. *American Journal of Public Health* 79(3): 310-15.

1. This study reviews 23 causes of injury mortality in children aged 0-14 in the United States between 1980 and 1985. The intent was to identify and assess the different causes of injury mortality in children.
2. Mortality tapes for the years 1980 through 1985 were obtained from the National Center for Health Statistics. Deaths of children aged 0-14 years, where the underlying event was injury, were analyzed. Expected numbers of deaths, based on the death rate for the U.S. as a whole, was calculated for each state. If the expected number of deaths to children for each state fell outside the confidence interval calculated around each state's observed number of deaths, the state's observed number of deaths was determined to be either significantly high or low. These states were depicted on a map.
3. Motor vehicles caused 37% of all injury-related deaths and were the leading cause of injury mortality in every group except children under one year of age. By comparison, drowning caused 14% of all injury-related deaths, house fires 12%, and homicide 10%. Between 1980 and 1985, there were a total of 22,174 motor vehicle-caused deaths to children between the ages of zero and fourteen. Of these, 7,489 children were pedestrians and 2,194 were bicyclists.
4. This study provides national-level statistics regarding the extent of motor vehicle-related fatalities to children in the U.S., including statistics regarding child pedestrian and cyclist fatalities. The data produced in this report shows that motor vehicle-related fatalities are the major source of injury-related fatalities in the U.S., and that a significant percentage of these fatalities are to pedestrians and bicyclists.

Wigan, M. Treatment of walking as a mode of transportation. *Transportation Research Record* 1487: 7-13.

1. This study was completed due to the lack of attention that walking as a form of travel has received in relation to other modes of transportation. The current concerns of governments and other agencies focus mainly on reducing the number of pedestrian injuries and deaths reported rather than working on ways to integrate walking into the treatment of mobility. This study breaks down walking and bicycling characteristics by age and gender while looking at statistics such as mean travel speeds, participation rates, and number of trips per day.

2. The data used for Wigan's analysis was derived from Australian travel surveys from 1986 which covered travel data from 18,000 people over 8 years old sampled from across Australia.
3. The analysis provided by Wigan show that the current integration of pedestrian behavior, demand, and policy is deficient. Wigan claims that there is no clear organization or agency that is responsible for pedestrian planning and by default it is taken on inadequately by groups interested in road safety.
4. Wigan stresses in his analysis that the contribution of non-motorized travel to fitness and the maintenance of mobility for the elderly should be taken into consideration when building communities. The author adds that we need to have a clear and more accurate assessment of non-motorized travel and that this will allow a more balanced allocation of resources and improvements to access and mobility.

III. Urban Form and Transportation

A. Literature on Transportation System Characteristics (Street Design, Street Networks, Street Users, Traffic Calming, Design for Pedestrian/Bicycle Zones)

Antonakos, C. 1994. Environmental and Travel Preferences of Cyclists. *Transportation Research Record 1438: 25-33.*

1. This study was conducted to contribute to the knowledge base on cyclists' opinions of how to improve cycling conditions. Transportation planners and engineers have relied on established standards when designing bikeways, standards which may or may not reflect the concerns and preferences of cyclists themselves.
2. The study pooled cyclists' opinions on environmental design issues. Surveys were administered to 552 cyclists in Michigan during the summer of 1992 to assess their preferences for different types of cycling facilities and the importance they placed on environmental factors such as traffic volume. Descriptive statistics summarizing preferences are provided, as are associational statistics.
3. Bike lanes, wide unmarked curb lanes, and bike paths are most preferred for recreational and commute cycling, with bike lanes being ranked highest for both types of cycling. Safe, quick, and direct routes are preferred for commuting, while traffic volume, surface quality, and scenery are the most important factors for choosing recreational routes. Bike safety programs for motorists and bicyclists are also valued. Many more cyclists responded that they run errands by bicycle than they commute, which means that facilitating errands by bicycle may be more effective at generating bicycling than facilitating the bicycle commute.
4. This study is one of the few to examine bicyclists' preferences. It complements design considerations for bicycling facilities.

Appleyard, D., and M. Lintell. 1982. The Environmental Quality of City Streets: The Residents' Viewpoint. In S. Kaplan and R. Kaplan (Eds.), *Humanscape: Environments for People*. Ann Arbor, MI: Ulrich's Books, Inc.

1. This study was conducted to determine the effect that increasing traffic volumes have on the livability and quality of the street environment.
2. Field observations and interviews were carried out on three similar San Francisco streets with differing traffic levels – defined as heavy, moderate, and light traffic volumes. The authors controlled for social class, education, and income. There were some differences in age, family composition, ownership, and length of residence. The

three study blocks were part of a residual Italian neighborhood. Two sources of information were used. Detailed interviews lasting about an hour were held with twelve residents on each block, representing about 30% of the households on each block. Second, systematic observations and measurements of pedestrian and traffic activity on the streets were carried out. Accident and noise level data were also generated.

3. The main findings support the idea that heavy traffic conditions reduce the livability of streets. The heavy traffic street produced more stress for its residents and led to less social interaction than the lightly trafficked street. Residents of the heavily trafficked street considered traffic to be more hazardous, stressful, polluted, and noisier and less socially interesting than those who lived on the lightly trafficked street. The authors also found that the mix of residents varied by street type. People who lived on the heavily trafficked street were more likely to be either old and/or poor (and thus unable to move) or young and single (with lower local socializing needs than families with younger children).
4. This study supports the claim that traffic volumes are predictive of and may influence behavior and psychological well-being. It is considered to be a landmark study.

Davis, A. 1998. Walking and Safer Routes to School. *Traffic Engineering and Control* (March 1998): 171-3.

1. This is a British study of the factors influencing children walking to school.
2. This study reviews and organizes prior research on the walk to school. The author discusses walking by age group and the key institutions involved in promoting walking to school.
3. The author stresses that it is possible to reverse declining rates of walking to school. This can be done by changing physical environments and by involving a variety of institutions, including schools. Collaborative efforts are needed.
4. This study provides a good summary of the problems related to declining rates of walking to school by children, and offers some solutions.

Dixon, L. 1995. Bicycle and Pedestrian Level-of-Service Performance Measures and Standards for Congestion Management Systems. *Transportation Research Record 1538: 1-9.*

1. This study reviews the bicycle and pedestrian level of service (LOS) performance measures and standards utilized by the city of Gainesville, Florida.
2. This study is analytical. It reviews and assesses the measures and standards for bicycle and pedestrian facilities used in the Gainesville Mobility Plan Prototype. It provides a description of the performance categories used for each type of facility, of the criteria used to evaluate facility performance in each category, and the scoring system used to quantify facility performance.
3. The bicycle and pedestrian LOS performance measures developed in Gainesville were tested on arterials and collector roadways. These results were reviewed by local citizens experienced in bicycle and pedestrian usage in the Gainesville area. Their personal experiences suggested that the assigned corridor LOS ratings accurately described existing bicyclist and pedestrian conditions. The author believes that the creation and use of LOS ratings systems that accurately convey bicyclists' and pedestrians' sense of safety, comfort, and convenience can assist in the identification of deficient facilities. Additionally, minimum LOS performance standards can be established for different types of facilities and incorporated in transportation planning.
4. This study provides an example of how one city conceptualized and constructed a LOS standard for bicycle and pedestrian facilities, how such a standard was tested against cyclists' and pedestrians' assessments of facilities, and how such a standard might be used to enhance the urban environment for nonmotorized traffic.

Döldissen, A. and W. Draeger. 1990. "Environmental traffic management strategies in Buxtehude." In R. Tolley (Ed.), *The Greening of Urban Transport: Planning for Walking and Cycling in Western Cities*. London: Belhaven Press.

1. This article summarizes one of six traffic management areas set up by the German federal government in the 1980s to facilitate walking and bicycling in urban areas. The project area reviewed by the authors composes the northern half of the town of Buxtehude in northern Germany.
2. The article is a largely qualitative discussion of the Buxtehude traffic management project. Before-and-after statistics of accidents involving cyclists are provided.
3. The project in Buxtehude aimed to make non-motorized transportation safer, quicker, more comfortable, and more attractive. The project involved changing street design elements in the northern half of the town. New bridges, cycle paths, and underpasses were built; more direct routes to town centers were created for cyclists and

pedestrians. At the time of writing, final figures weren't available on modal split changes but cycling levels had increased 40%. Pedestrian accidents decreased 46% and cycling accidents increased 32%, which was considered by the authors to represent a risk reduction given the increase in cycling traffic.

4. This study supports the proposition that urban redesign can increase physical activity levels. It adds information to how Germany has facilitated bicycling and walking through public policy.

Epperson, B. 1994. Evaluating Suitability of Roadways for Bicycle Use: Toward a Cycling Level-of-Service Standard. *Transportation Research Record 1438*: 9-16.

1. This study reviews attempts by scholars to devise level of service (LOS) standards for bicyclists, asks whether such measurements are useful, and provides an assessment of further work required in this area.
2. The bulk of the study reviews previous attempts at devising quantified LOS standards for bicyclists. In so doing, the study reviews the variables considered to be important under different measurement schemes, presents the models (equations) that have been developed, and provides examples of how these standards would quantify street conditions for bicyclists.
3. The author asserts that, taken together, recent efforts have come close to developing a practical and meaningful cycling LOS standard. These efforts have focused on five descriptive factors: per-lane traffic volume, speed of traffic, right-hand-lane width, overall pavement quality, and the generation of conflicting travel paths between bicycles and motor vehicles. The author believes that a functional bicycle LOS standard could be integrated into transportation forecasting models now used to plan roadway and transit networks, facilitating a multimodal development framework.
4. This study is useful in generating a better understanding of how some transportation researchers are attempting to devise measures for nonmotorized modes of transportation that are similar to those for motorized transportation. Additionally, this study provides arguments regarding the use and utility of such measures.

Eubank-Ahrens, B. 1987. A Closer Look at the Users of Woonerven. In A. Moudon (Ed.), *Public Streets for Public Use*. New York: Van Nostrand Reinhold Co., Inc.

1. This study addresses the impact of street redesign on the behavior of nonmotorized street users in Hannover, Germany. The author looked at the impact of one type of street redesign, the woonerf design concept, in one neighborhood. The purpose was

to ascertain whether the redesign resulted in both more street usage by different subgroups within the population and different types of social interaction.

2. The author was interested in the behavior of nonmotorized users of street space in two streets in a dense, inner city neighborhood. She observed and recorded both the numbers and behaviors of persons who elected to stay on the streets for durations of at least one minute; she made such observations before and after the streets were redesigned. Descriptive data are provided in a series of charts and tables. Maps and photographs complement the discussion.
3. Street redesign in this neighborhood was found to be particularly supportive of children's play, but had fewer far-reaching social consequences for adults. The types of children's play proliferated, and children's involvement with the physical environment generally increased. Adult social interaction did not increase substantially.
4. This study supports the idea that streets are important spatial areas for children. The study does not generally support the idea that traffic calming will dramatically increase walking and bicycling levels. The study is primarily oriented toward sociological questions.

Ewing, R. 1997. *Transportation and Land Use Innovations: When You Can't Pave Your Way Out of Congestion*. Chicago: American Planning Association.

1. This handbook is written as an introductory text for community leaders interested in transportation mobility problems. It offers suggestions for reducing congestion, automobile dependence, and vehicle miles of travel.
2. This handbook presents alternative ways of conceptualizing mobility and solving congestion problems. To support arguments, the author relies upon many examples of local and state initiatives that are considered to be novel in concept and/or implementation. The book makes extensive use of secondary data to support key points in the text. Maps, tables, charts, and figures are prominent throughout.
3. The key premise of this report is that road-building will not solve congestion problems. The author's intent is to present an alternative set of transportation planning ideas, including the need for coordination between land use planning and transportation planning, proper design of streets, street networks, and buildings to facilitate non-motorized traffic, and the creation of appropriate transportation performance measures.
4. While this handbook introduces no new primary data, it is nonetheless a digestible summary of the major concepts involved in planning for decreasing reliance upon the automobile and increasing reliance upon non-motorized transportation.

Ewing, R. 1994. Residential Street Design: Do the British and Australians Know Something Americans Do Not? *Transportation Research Record 1455: 42-9.*

1. This article compares American, British, and Australian street design guidelines governing geometrics, sidewalk warrants, intersection treatments, network design, and traffic-calming measures.
2. The author seeks to compare residential street guidelines in these three countries, using authoritative design manuals commonly used in each country. Three American, two British, and three Australian manuals are used.
3. British and Australian guidelines provide for narrower pavement surfaces, sharper horizontal curves to control speeds, roundabouts and T-intersections, more efficient networks, and a wide array of traffic-calming devices. The author asserts that Americans have fallen behind the British and Australians in the conception of residential street functions and approaches to traffic management.
4. This article provides a helpful review of street design practices in the U.S. and abroad, and suggests how widely-accepted design standards in the U.S. are biased in the direction of fast-moving automobiles.

Federal Highway Administration. 1994. *The Effects of Bicycle Accommodations on Bicycle/Motor Vehicle Safety and Traffic Operations.* Publication No. FHWA-RD-92-069. Washington, D.C.: U.S. Department of Transportation.

1. This report's main objective was to develop a manual for selecting roadway design treatments to accommodate bicycles. Included in this objective were the establishment of the traffic operational conditions that determine when to provide different types of bicycle facilities and the development of a procedure for selecting the most appropriate roadway design that considers the needs of all highway users.
2. A project team utilized a variety of sources to create this manual, including a review of domestic and foreign literature to establish the state of the practice in bicycle facility planning and design, consultation with practitioners in the field, and the results of a number of field studies. Results from the field studies provide original data.
3. This report is similar in intent and findings to Federal Highway Administration, *Selecting Roadway Design Treatments to Accommodate Bicycles* (1994). This report is more exhaustive, discussing in greater detail the design considerations inherent in the different types of bicycle facilities. It also contains a section on European bicycle facilities and a section on the results of a series of field studies that were conducted to determine what effect bike lanes and wide curb lanes had on safety and traffic

operations. However, the section on design selection and specifications for bicycle facilities is nearly identical to that contained in the other FHWA report.

4. This report is similar to Federal Highway Administration, *Selecting Roadway Design Treatments to Accommodate Bicycles* (1994). However, it provides a longer, more exhaustive discussion of how to define the criteria for the design of roadways to accommodate bicyclists. It also adds two unique sections, on European design perspectives and on the results of the field studies.

Federal Highway Administration. 1994. *Selecting Roadway Design Treatments to Accommodate Bicycles*. Publication No. FHWA-RD-92-073. Washington, D.C.: U.S. Department of Transportation.

1. This manual was designed to assist transportation planners and engineers in the selection of roadway design treatments to accommodate both bicycles and motor vehicles.
2. This report describes a set of assumptions and principles used to develop recommendations for the selection of roadway design treatments to accommodate bicycles, including the accommodation of bicycling on all streets and highways on which bicycling is permitted. It lays out a planning process that can be used to identify a network of routes on which designated bicycle facilities should be provided to accommodate bicyclists of moderate ability. Finally, it presents recommended designs for roadways to serve different types of bicyclists under various sets of traffic and operational factors. A series of charts are presented to assist in the determination of appropriate design standards for different types of roadways.
3. This report considers the design specifications for bike paths, lanes, and shoulders. This report recognizes two types of bicyclists, advanced adults and basic adults/children. It assumes that all streets where bicycling is permitted should be designed to accommodate shared use by bicycles and motor vehicles. The appropriateness of a design treatment depends on a set of roadway conditions, such as traffic mix and volume, average traffic speed, sight distances, and number of intersections. The report defines design categories for each of these roadway conditions, for example it creates three categories of traffic volume, high, medium, and low, with "high" defined as over 2,000 vehicles per day. A series of tables is presented that define the type of bicycle facility design treatment for different roadway conditions.
4. This report is a technical document that provides the reader with one set of recommendations regarding how to define the criteria for the design of roadways to accommodate bicyclists.

Federal Highway Administration. 1994. *Traffic Calming, Auto-Restricted Zones and Other Traffic Management Techniques – Their Effects on Bicycling and Pedestrians. National Bicycling and Walking Study, FHWA Case Study Number 19.*

1. This study looks at traffic calming measures that have been implemented over the past thirty years across Europe, Japan and the United States. As traffic calming measures have been particularly widespread in western Europe, the potential impact of traffic calming measures on motorized and non-motorized transportation patterns was considered worthy of attention by FHWA analysts conducting the National Bicycling and Walking Study.
2. This study reviews the experiences of traffic calming measures undertaken in various cities in Europe, Japan and the United States. Quantitative and qualitative information from published studies is used by the authors to summarize lessons. The study examines the policy implications of the traffic calming measures.
3. Traffic calming reduces the dominance of motorized vehicles through a variety of street design measures aimed at raising the status of pedestrians and bicyclists and slowing the speed of motorized vehicles. Western European cities invented traffic calming measures in the 1960s and 1970s and perfected techniques in the 1980s. The goal of traffic calming measures in Europe has been to decrease accident rates involving pedestrians and bicyclists and to enhance the quality of the urban environment. Reviews of traffic calming measures undertaken in Europe are presented as being successful in, among other things, reducing traffic speeds, increasing bicycle and pedestrian traffic, and reducing accidents. The review of American and Japanese measures is less exhaustive due largely to fewer cases.
4. This study supports the position of those who wish to link urban form variables with physical activity levels, pedestrian and bicyclist safety, and other social and environmental issues. The strength of the study lies in its review of traffic calming projects from around the world.

Forkenbrock, D. and L. Schweitzer. 1997. *Environmental Justice and Transportation Investment Policy. Iowa City, IA: Public Policy Center, University of Iowa.*

1. The objective of this study was to develop a series of practical indicators of the economic, social, and environmental impacts related to transportation system changes and to compare the spatial impacts of these impacts with the locations of low-income and minority populations.
2. The authors obtained state-of-the-practice transportation models from government agencies and integrated them into a geographic information system (GIS). The intent was to examine the spatial nature of relevant impacts. The authors then tested their

spatial analysis methods using the Highway 63 corridor in Waterloo, Iowa, as a trial application. This corridor is comparatively diverse in terms of race and income. Additionally, the authors also discuss many of the issues that are central to the implementation of environmental justice.

3. The authors field tested their model of transportation's impact on minority and low income communities in four areas: noise, air pollution, and economic and social impacts. The most relevant chapter, however, for the purposes of this literature review is a chapter on the implementation of environmental justice. The authors provide a useful review of literature regarding the negative impacts of high volumes of motorized traffic on neighborhood cohesion and functioning, including neighborhood safety, sociability, and aesthetics. Involved in the former is a discussion of the state of research into the dangers of traffic safety for children.
4. This study provides an example of one way to operationalize the negative effects of traffic volume on low-income and minority neighborhoods. However, the discussion on the state of research into the types of negative impacts that transportation investments, particularly high-traffic-volume freeways, have on communities is the most relevant to our topic. Within this subject, the discussion on childhood mobility is most useful.

Grava, S. 1993. Traffic Calming – Can it Be Done in America? *Transportation Quarterly* 47(4): 283-305.

1. This study is a qualitative review of traffic calming schemes in New York City.
2. The author reviews the traffic calming phenomenon in Europe, provides a few U.S. traffic calming examples, and provides a qualitative review of traffic calming schemes in New York City. The technique employed is descriptive.
3. This study generates few generalizable conclusions. Traffic calmed streets in New York City are few, with the ones that exist most often having been built before World War II.
4. This study provides additional information regarding how traffic calming is to be conceived, with specific examples from the American context.

Greenways Incorporated. 1992. *National Bicycling and Walking Study, Case Study 24: Current Planning Guidelines and Design Standards Being Used by State and Local Agencies for Bicycle and Pedestrian Facilities*. Prepared for the U.S. Department of Transportation, Federal Highway Administration. Washington, D.C.

1. This case study identifies and reviews selected federal, state, and local bicycle and pedestrian planning guidelines and design standards. As the title indicates, the majority of the report is dedicated to state and local guidelines and standards.
2. This case study describes bicycle and pedestrian guidelines, standards, and programs at the federal, state, and local levels. There is no indication of best practices. The text does, however, provide qualitative evaluations of each individual plan or program. Similarities and differences among guidelines and standards are offered. Additionally, the report makes heavy use of figures showing different types of design guidelines (for example, diagrams for creating bicycle left-turn lanes, bikepath intersections, bicycle sign details, etc.).
3. As the great bulk of this report is dedicated to identifying and describing guidelines and standards, no generalizable conclusions are provided.
4. This review is a helpful reference for those wishing to get a better understanding of how some states and localities set design guidelines for bicycle and pedestrian facilities.

Hartman, J. 1990. "The Delft bicycle network." In R. Tolley (Ed.), *The Greening of Urban Transport: Planning for Walking and Cycling in Western Cities*. London: Belhaven Press.

1. This article summarizes the experience of the city of Delft, Holland in implementing an experimental bike path network.
2. The study provides a description of the creation of a bicycle network in Delft and the results of a before-and-after study of the network. It presents descriptive statistics regarding changes in modal choice, attitudes toward cycling, route choice, and usage of the network.
3. The before-and-after study of the creation of the bike path network found that there was evidence of a modal shift away from automobiles and toward bicycles. A survey of attitudes found that the cycling environment had improved. The distance traveled by bicyclists increased but travel time did not, indicating increases in average bike speed on the paths. A fine network grid pattern and good continuity between destinations likely enhances usage.

4. This study adds to information about bicycling in Holland, a leading country in the area of non-motorized transport. Delft's bike path network lends support to the proposition that the construction of bicycle networks will increase levels of bicycling.

Hope, D. 1994. *Nonrecreational Cycling in Ottawa, Canada*. Transportation Research Record 1441.

1. This paper was written to describe Ottawa's nonrecreational cycling environment. Ottawa, recognized as the city most conducive to cycling in Canada, has developed a series of policy documents and plans designed to further increase cycling as a form of transportation in the city.
2. This is a descriptive summary of the cycling environment in Ottawa. The paper briefly reviews cycling's history in the city, starting with the construction of a large network of bike paths in the 1970s. Summaries of two 1991 surveys of cyclists made are presented, as are policy initiatives made by the city government to increase nonrecreational cycling.
3. The paper describes how Ottawa is shifting policy emphases from the provision of facilities for recreational cycling to those for nonrecreational cycling. The authors infer that the creation of an extensive network of bike paths in the 1970s created a surge in popularity for cycling and other forms of physical activity, which in turn prompted public officials to expand the city's programs to increase nonrecreational cycling.
4. This study provides anecdotal evidence that the providing bicycling facilities will increase the level of bicycling and that there is considerable latent demand for bicycling. It describes how the successful introduction of bike paths in Ottawa provided a basis for further political action by the city to further increase bicycling efforts.

Hülsmann, W. 1990. "The 'Bicycle-Friendly Towns' project in the Federal Republic of Germany." In R. Tolley (ed.), *The Greening of Urban Transport: Planning for Walking and Cycling in Western Cities*. London: Belhaven Press.

1. This article reviews the "Bicycle-Friendly Towns" project in two cities in Germany.
2. The author reviews the origin of the project at the federal level in Germany, the selection of the pilot cities, the project's central design features, and presents summary results (e.g., shifts in modal choice).
3. The aim of the project, conceived and announced in 1979, was to promote cycling in Germany. Two cities were selected by the federal environment agency from 130



applicants; both indicated a willingness to construct a bicycle network but both had poor existing bicycle infrastructure. Results from both cities for the period 1981 to 1986 indicated a shift in modal choice toward the bicycle. Motorized traffic levels were held constant despite increases in vehicle ownership. The project was completed in 1988. The author provides recommendations on building successful bicycle-friendly towns based on the project's experiences.

4. This article adds information to our understanding of cycling in Germany, a country considered a leader in non-motorized transport. The results of the projects summarized in the article provide support to the idea that urban bicycle networks can shift modal choice. Design and promotional considerations for successful networks are provided.

Khisty, C.J. 1994. Evaluation of pedestrian facilities: Beyond the level-of-service concept. *Transportation Research Record 1438*: 45-50.

1. Khisty proposes that there is a great need to re-evaluate the criteria used to design and evaluate pedestrian facilities. The guidelines we currently use to design pedestrian facilities are taken from the 1985 Highway Capacity Manual which uses the concept of level-of-service, the same concept used for automobile facility design. Khisty implies that we cannot design pedestrian facilities with the concepts used for highway design.
2. After reviewing the literature on traffic engineering and environmental psychology, the author came up with a list of seven performance measures that would more accurately evaluate level-of-service for pedestrian facilities. These performance measures were attractiveness, comfort, convenience, safety, security, system coherence, and system continuity. The setting for this study was the Illinois Institute of Technology in downtown Chicago. Six hundred survey forms were distributed to students, staff, and faculty to apply the methodology. The seven performance measures were given a weighting factor according to LOS. The results of the survey provided the level of service for 15 different routes and segments of routes on the IIT campus.
3. The article presented the results from 2 of the 15 routes. Using the weighting scale, the first route received a LOS grade of slightly better than a D and the second route received a LOS grade slightly better than a B. These results can be used as a tool to guide decision makers in evaluating the quality of pedestrian facilities beyond just the qualitative factors (flow, speed, and density).
4. The evaluation of pedestrian facilities is an important tool in improving the total transportation system. Using qualitative factors in addition to quantitative ones can more accurately evaluate pedestrian facilities. The results of the use of this methodology can be used to program improvements to the pedestrian environment and reduce the barriers to walking. Presumably, this would allow for greater participation in recreational and utilitarian physical activity.

Litman, T. 1999. *Quantifying the Benefits of Non-Motorized Travel for Achieving TDM Objectives*. Victoria, British Columbia: Victoria Transport Policy Institute.

1. This paper explores two questions. First, it examines the benefits that result when walking and cycling substitute for automobile travel. Benefits are quantified into monetary terms. Second, it discusses strategies to encourage pedestrian and bicycle transport.
2. The author lists the benefits from a modal shift away from autos to bicycles and walking (e.g., reduced congestion, noise, and air pollution) and then quantifies the benefits in monetary terms. The author relies on previous studies to set baseline monetary figures. The dollar amounts from each benefit are summed to produce a benefit figure per trip. The author also summarizes a wide variety of literature on the barriers to increased biking and walking and strategies to overcome these barriers.
3. The author found that the benefits of a modal shift range from \$1.05 per trip in rural areas to \$3.58 in urban areas during peak hours. The author's discussion of these benefits, of the barriers to increased walking and biking, and of strategies to overcome the barriers are well-organized and extensive.
4. This study supports the position of bicycling and pedestrian advocates by emphasizing and quantifying the benefits of a modal shift away from automobiles. The quantification process is simple; no new data is assembled. The summaries of barriers and strategies to overcome the barriers are well-organized and well-written.

Monheim, R. 1990. "Policy issues in promoting the green modes." In R. Tolley (Ed.), *The Greening of Urban Transport: Planning for Walking and Cycling in Western Cities*. London: Belhaven Press.

1. This article reviews the political and social structures surrounding Germany's implementation of bicycle- and pedestrian-friendly urban areas starting in the 1970s.
2. The author examines the constellation of actors at the federal, state and local levels who were involved in transportation policy in Germany during the 1970s and 1980s. The activities of governmental bodies, citizen groups, and corporations are examined.
3. The author asserts that the shift in German attitudes toward urban redesign in favor of the bicycle and pedestrian occurred largely in spite of official and corporate positions on the subject. Rather, the impetus for reform came largely from a few actors in the face of larger indifference. Expert opinion has consistently underestimated the success of bicycle- and pedestrian-friendly urban redesign experiments.

4. This study is relevant in that it adds to an understanding of how transportation policy in Germany, a country considered a leader in bicycle- and pedestrian-friendly transport, is formulated. It reviews how change occurred in a policy environment largely oriented toward the automobile. It also asserts that much is needed to be done in Germany, as of the date of writing (1990).

Moe, R. and K. Reavis. 1997. *Pedestrian Level of Service*. Fort Collins, CO: Balloffet and Associates, Inc.

1. This study provides a description of the measurements that comprise the city of Fort Collins' pedestrian level of service (LOS) standard.
2. The bulk of this study describes the different measurements used by the city of Fort Collins, Colorado in its LOS standard for pedestrians. The core of the study consists of a matrix, with LOS measures arrayed on the vertical axis and the levels of service (A to F, with "A" representing the highest pedestrian level of service) arrayed on the x axis.
3. The measures that were devised by the city to comprise its pedestrian LOS standard are directness (ratio of street pattern needed to walk from point A to B versus "crow fly" distance), continuity (sidewalk system completeness), street crossings (e.g., presence of crosswalks and medians, lighting levels), visual interest and amenity (pedestrian system's attractiveness and features) and security (pedestrians' sense of security). Each measure is matched to a level of service standard ("A" to "F", with "A" being the highest level of service). The study also reviews the city's pedestrian facilities plan, which defines acceptable LOS thresholds by type of activity area. Pedestrian districts are defined and are given a higher LOS threshold; conversely, outlying residential areas are allowed to have lower LOS thresholds.
4. This study is useful in illustrating how one small city has utilized the LOS concept to devise a concrete plan for gauging the walkability of different parts of the city. The study generates an understanding of how pedestrian standards can be created and used to define minimum service thresholds.

Moore, R. 1987. *Streets as Playgrounds*. In A. Moudon (Ed.), *Public Streets for Public Use*. New York: Van Nostrand Reinhold Co., Inc.

1. This study addresses the ways in which children perceive streets. The author attempts to demonstrate that streets are indispensable spatial areas for children's play.
2. This study is analytical. The author utilizes little quantitative data, relying instead on observations of children at play and previous studies of child behavior in urban environments. Illustrative maps and photographs are provided.

3. The primary argument in this study is that children make substantial use of streets and street-related spaces, and that use is unlikely to change. The bulk of the study is devoted to explaining why streets are amongst the most attractive play environments for children. Amongst other things, streets: are easily accessible environments for children; are places where there are few rules imposed upon children's play; contain many interesting artifacts (e.g., parked cars, gutters, manhole covers, roadside trees, mailboxes, and grass strips, etc.) that can easily be turned into play objects. As a result of their attractiveness to children, Moore argues that streets cannot be banished as play areas for children and thus ought to be made safer.
4. Moore's study is useful in that it provides insights into how one group perceives and uses streets.

Moritz, W. 1997. Survey of North American Bicycle Commuters: Design and Aggregate Results. *Transportation Research Record 1578: 91-101.*

1. The goal of this study of bicycle commuters in the United States and Canada was to develop a demographic profile of this group and to understand the types of facilities that are considered safe and unsafe by bicycle commuters.
2. A comprehensive survey was conducted by mail and over the Internet. 2,374 responses were received from all regions of the U.S. and Canada. Information was gathered in 7 categories: commuting; facilities; bicycle information; motivation; safety/accidents; health; household information.
3. According to this study, the average bicycle commuter is a 39-year-old male professional with a household income of \$45,000 per year who rides 10.6 months per year. Nearly one in five were females. Riding on sidewalks was considered by the cyclists to be the most dangerous facility in terms of frequency of accidents, followed by major streets without bicycle facilities, minor streets, streets with bike lanes or routes, and bike paths.
4. This study provides useful demographic information about riding characteristics, and provides helpful data regarding which types of bicycle facilities are considered to be the best by bicycle riders themselves.

Moritz, W. 1998. Adult Bicyclists in the United States: Characteristics and Riding Experience in 1996. *Transportation Research Record 1636: 1-7.*

1. This paper presents a the results of a League of American Bicyclists survey conducted in 1996.
2. 1,956 members were surveyed about their cycling experiences in 1996. 33 questions were asked, covering bicycle type, bicycle trips by purpose, total distance cycled, commuting habits, accidents, and demographic data.
3. The typical respondent was a 48-year-old married male professional who rode 4670 km in 1996. Over 9% reported an accident in 1996. Falls accounted for 59% of the accidents, running into fixed objects 14%, other bicycles 9%, and motor vehicles 11%. A danger index shows that streets with bike lanes have a significantly lower crash rate than either major or minor streets without any bicycle facilities. Cycling on the sidewalk is extremely dangerous.
4. This study provides useful data about traveling behaviors and accident patterns for avid bicyclists. It also provides indicators of which facilities have proven to be safer for this group of bicyclists.

Moudon, A. and R. Untermann. 1987. Grids Revisited. In A. Moudon (Ed.), *Public Streets for Public Use*. New York: Van Nostrand Reinhold Co., Inc.

1. This article reviews the history of the grid street pattern in American urban history, and identifies as a potential source of urban redevelopment the large amount of street space contained in grid patterns.
2. This is a qualitative study. The authors first review the history of the grid pattern in American urban history, then discuss the possibility that underutilized street space in grid networks can be used for different purposes than moving motorized traffic.
3. The authors contend that many American city streets are generous in their dimensions, a situation that allows for conversion of space into other uses. They contend that it makes sense to use street space to combat pervasive urban problems, including overdevelopment, noise and air pollution, parking, lack of green space, and pedestrian safety. Finally, they believe that it would be neither difficult nor expensive to increase the public utility of streets by encouraging that the space be shared by several uses and users.
4. This study addresses the issues of urban design and transportation. Streets are seen as spaces that should not be thought of only as places for motorized vehicles.

Mozer, D. 1998. *Bicycle and pedestrian friendly planning and land-use code*. International Bicycle Fund.

1. This article, produced by the International Bicycle Fund, gives the reader insight into what makes a livable environment and how we perceive our environment.
2. The article could be used as a guide by local cities and municipalities in order to create a more livable society. The author shows how our perceptions and commuting habits change according to the physical environment that we live in. He uses the cities of Amsterdam, Manhattan, and Los Angeles as an example. Mozer claims that travel choice is determined not by culture but by the built environment.
3. The main point of this article is to explain that a quality urban environment should include safety considerations, proximity and access, and not simply mobility.
4. This article provides a synthesis of how to make a community more livable. The author successfully shows for instance, that the car culture found in Los Angeles is not due to Angelenos' love for their cars but rather the sprawling design of their city.

Nielson, O. 1993. Safe routes to school in Odense, Denmark. In Tolley (ed.), *The Greening of Urban Transport: Planning for Walking and Cycling in Western Cities*. London: Belhaven Press.

1. This study examines the child bicycle and pedestrian safety project undertaken by the city of Odense, Denmark. This project was begun in the late 1970s in order to reduce the incidence of injuries and deaths to children who walk or bicycle to school.
2. This study is a qualitative review of the Odense "safe routes to school" project. The bulk of the text describes the origins of the project, its planning and implementation, and its results. Some before-and-after data is presented. The text is supported by photographs and maps.
3. The author reports that between 1955 and 1971 Denmark had the highest rate of child mortality due to road accidents in western Europe. In the late 1970s, Odense, a city with a population of about 150,000 residents, began a local initiative to reduce injury and deaths to children. In Odense, fewer than 5% of children go to school by car. The project was very novel in that it involved first getting children to define those areas of their routes to school they considered to be most hazardous, only after which parents and teachers made comments and submitted proposals for street design changes. Since 1981, 185 proposals have been submitted with 65 being implemented as of the late 1980s. A few before-and-after case studies were conducted. Amongst other things, these showed that traffic calming measures effectively reduced vehicle speeds
4. This case study is useful in describing how one city established a process to define traffic problems and implement solutions in order to increase the ability of children to safely walk or bike to school.

Project for Public Spaces. 1993. *The Effects of Environmental Design on the Amount and Type of Bicycling and Walking*. National Bicycling and Walking Study, Federal Highway Administration. FHWA Case Study Number 20.

1. The impetus for this study is the proliferation of design improvements in downtown areas of American cities since the 1960s to make the environment friendly to pedestrians and bicyclists.
2. This review summarizes and categorizes the lessons from nearly four decades of projects in American cities. Typologies of pedestrian and bicycle improvements are presented and a summary of experiences is made for each type. Factors considered important in the creation of effective walking and bicycling environments are presented.
3. The authors believe that integrated streetscape planning is essential if successful pedestrian and bicycling environments are to be created. Street design considerations must include how to meet the needs of pedestrians, bicyclists, drivers, shopkeepers and a host of others. Successful walking and bicycling environments cannot exclude motor vehicles.
4. This report supports the agenda of those who advocate non-motorized travel in urban areas, but its policy prescriptions also recognize the complex nature of the problem and the important role played by vehicles in the creation of successful streetscapes. The report contains a wealth of examples of redesigned downtown areas that have been successful or unsuccessful in facilitating walkable and bikable streetscapes.

Pucher, J. and C. Lefevre. 1996. *The Urban Transport Crisis in Europe and North America*. London: Macmillan Press Ltd.

1. This book was written to examine and compare the transportation systems of cities in European and North American countries. The reason for doing so is to address the questions of why traffic congestion in these affluent countries is a common problem, and what policies mitigate this problem.
2. This book is organized into three parts, an introduction and overview, in-depth case studies of eight countries (Germany, France, the Netherlands, Italy, Great Britain, Canada, the United States, and one grouping of countries, Eastern Europe), and a summary comparative evaluation and policy recommendations. For each country, the authors examine trends in urban spatial structure and urban transport problems and the public policy responses to these problems. Descriptive statistics are provided.

3. The authors conclude that while the U.S. has long been the most auto-dependent society in the world, modal trends in Europe and Canada have been following the American example, with car usage increasing each year. Decentralized urban settlement patterns are problematic also in Europe. In general, public policies have failed to provide viable transport alternatives to the automobile. Policy solutions to the economic, social, and environmental consequences of an excessive reliance on the automobile have almost everywhere been weak; improved automobile technology has almost everywhere been seen as a politically palatable solution. Transport policy has almost everywhere been sectoral, with virtually no integration into larger urban planning schemes. This has had major consequences for the patterns of urban development. Some countries such as the Netherlands and Germany have managed to implement policies designed to provide alternatives, however. Overall, the authors believe that powerful economic lobbies and political pressures hinder the adoption of policies to increase the cost of auto usage.
4. This book provides a much-needed comparative assessment of urban transport problems and policies across wealthy countries. The in-depth case studies shed light on how transportation systems in different countries have developed, and what policies have been used to advance and hinder different transport modes.

Rapoport, A. 1987. Pedestrian Street Use: Culture and Perception. In A. Moudon (Ed.), *Public Streets for Public Use*. New York: Van Nostrand Reinhold Co., Inc.

1. This study addresses the variables that influence the use of streets by pedestrians. The author attempts to define and delineate the perceptual characteristics of streets that encourage or discourage street use by pedestrians on the one hand and high-speed traffic on the other.
2. This study is analytical. The author utilizes no quantitative data. Rather, the article is centered around a few concepts regarding how individuals traveling at different speeds (slow rate of speed for pedestrians versus higher rates of speed for drivers) will perceive the built environment. Conversely, Rapoport analyzes the impact that the built environment is likely to have on the pedestrian and the driver.
3. This study generates no empirically-based findings. Its conclusions are speculative, based upon an analytical argument of how individuals perceive the built environment. Rapoport asserts that the built environment will discourage walking if streets and buildings fail to offer a sufficient level of detail, complexity, and asymmetry. Conversely, high-speed driving requires low levels of detail, symmetrical street patterns, gradual street curves, wide roads, and simple buildings. High-speed driving and walking are therefore considered to be mutually exclusive activities.
4. While not an empirical study, Rapoport provides an argument as to why it may be difficult to induce walking along roads designed for high-speed traffic.

Sarkar, S. 1994. Determination of Service Levels for Pedestrians, with European Examples. *Transportation Research Record 1405*: 35-42.

1. This study defines the ideal pedestrian environment and classifies pedestrian environments into six service levels.
2. This study consists of a qualitative assessment of pedestrian environments, using observations made by the author of different pedestrian environments in two cities, Rome and Munich. After observing the levels of activity and use in these environments, the author classified pedestrian environments into six service levels, service level "A" (best) through "F" (worst). A standard is defined for six measures within each service level: pedestrian safety, security, convenience and comfort, continuity, system coherence, and attractiveness. Illustrative photographs of different service levels in pedestrian environments in Rome and Munich are provided.
3. The author concludes that the ideal pedestrian environment would accord exclusionary rights to pedestrians (service level A): prohibiting vehicular traffic and providing an environment rich in qualitative elements for diversified pedestrian environments. However, such an arrangement would be unrealistic over the great bulk of a city's space, so a more realistic solution would be to foster pedestrian areas with service level B, where the right of way is shared by different modes through horizontal and vertical grade separation and attention is given to make the pedestrian environment user-friendly. The author asserts that traffic planners and designers ignore the importance of intermodal connectivity and the facilities that enhance such transfers.
4. This study provides another useful example of how to conceptualize and construct a LOS standard for pedestrians, and how such a standard might be used to enhance the pedestrian environment in real cities.

Untermann, R. 1987. Changing Design Standards for Streets and Roads. In A. Moudon (Ed.), *Public Streets for Public Use*. New York: Van Nostrand Reinhold Co., Inc.

1. This article reviews the evolution of street design standards in the United States since the 1950s.
2. This is an issue-oriented study. No quantitative analysis is conducted.
3. The author's primary thesis is that road design standards in the United States have increasingly come to favor the automobile and the truck over the bicycle and pedestrian. They have done so through emphasizing roads that are wider, smoother, and straighter, conditions that allow motorized vehicles to travel at faster speeds for

sustained periods of time. This development is seen by the author as the result of intensive and sustained lobbying by automotive, trucking, and oil companies from the 1950s through the 1980s. Untermann also includes a section on changes to design standards that would encourage more walking and bicycling, such as reducing arterial road widths, reducing intersection radii, mandating sidewalk construction, creating pedestrian islands, and other alterations.

4. This article provides an argument regarding why American road design standards have come to favor motorized traffic. Additionally, it provides suggestions regarding design changes that would favor nonmotorized traffic.

Whitelegg, J. 1993. The principle of environmental traffic management. In Tolley (Ed.), *The Greening of Urban Transport: Planning for Walking and Cycling in Western Cities*. London: Belhaven Press.

1. This article reviews traffic management schemes in Germany. It attempts a review of some of the measures taken to limit the negative effects of Germany's automobile-dominated transportation system.
2. This is an issue-oriented article. Some descriptive data reporting accident statistics in selected German cities is reported. A few maps are also used.
3. The majority of the article is devoted to a discussion of traffic calming schemes in German cities. The author reports that by the 1980s a consensus had begun to develop in Germany that called for dramatically lowered traffic speeds in urban areas, increased capacity for buses, rail, pedestrians, and cyclists, and a decrease in the amount of short-term parking. In those cities that have undertaken comprehensive traffic calming schemes, data shows that redesigned areas have seen lower traffic speeds and increased safety for cyclists and pedestrians. However, German cities continue to be under intense pressure due to increased auto ownership and usage, and areas outside those that have been redesigned are not nearly as friendly for pedestrians and cyclists.
4. This article describes traffic calming policies in Germany, one of the countries widely acknowledged to be at the forefront of street redesign. Quantified results of some traffic calming experiments in German cities are reported.

Wolfe, C. 1987. Streets Regulating Neighborhood Form: A Selective History. In A. Moudon (Ed.), *Public Streets for Public Use*. New York: Van Nostrand Reinhold Co., Inc.

1. This article reviews the history of the planning debate over street patterns and neighborhood form in the United States.

2. The method is explicitly historical and qualitative. The core of the article is a review of planners' and architects' arguments surrounding the neighborhood street network in early 20th-century America.
3. This chapter is primarily devoted to discussing the origins of the modern suburban neighborhood. During the early decades of this century, planning reformers sought to alleviate the monotony of the grid street network and improve safety in neighborhoods by introducing curvilinear, disconnected, and localized street networks. The focus of planning was to shift from the city to the neighborhood; to improve safety, neighborhoods were increasingly seen as needing to be cut off from the city's traffic. Traffic was seen as needing to be routed along major arterials. Curvilinear, disconnected streets were introduced within neighborhoods in order to discourage through traffic. These basic design principles came to be widely accepted in postwar planning circles.
4. This review of the evolution of planning in the United States is helpful in explaining how American neighborhood design came to be dominated by disconnected, hierarchical, curvilinear street networks.

Wynne, G. 1992. *A Study of Bicycle and Pedestrian Programs in European Countries*. National Cycling and Walking Study, Federal Highway Administration. FHWA Case Study Number xxxxx

1. This study reviews bicycle and pedestrian measures and policies that have been undertaken in European countries.
2. This study is a qualitative review of public policies and private initiatives in different European countries. Documents from each country are reviewed by the author and categorized and discussed by topic.
3. The report finds that European countries, particularly in the north and west, have invested heavily in producing urban environments conducive to bicycling and walking. National and local plans and measures are reviewed; basic statistics are provided. Measures to reduce motorized vehicle speeds in urban areas have worked in slowing average speeds and in reducing traffic accidents. Pedestrian amenities are widespread in central districts of most cities and have succeeded in increasing foot traffic. European countries and cities have also invested in bicycle safety programs, have improved access for cyclists to public transportation, have promoted bicycle-friendly practices through demonstration programs and contests, and have designed other programs to subsidize bicycle use.

4. This is a lengthy summary of bicycle and pedestrian programs in Europe, a continent where there has been a significant amount of innovation regarding the facilitation of bicycle and pedestrian travel.

Zein, S., Geddes, E., Hemsing, S., and M. Johnson. 1997. Safety Benefits of Traffic Calming. *Transportation Research Record 1578*: 3-10.

1. This study was conducted to determine whether there are quantifiable collision-reduction benefits that result from traffic calming.
2. Four local traffic-calming projects in the Vancouver area were selected, and collision data gathered for at least one year prior and after implementation of traffic calming measures. Data was categorized by collision type, and before-and-after comparisons were made regarding changes in collision frequency and annual collision claim costs in these areas. A separate analysis of 85 international case studies was also conducted.
3. On average, the four Vancouver case studies witnessed a 40% decrease in collision frequency and a 38% decrease in annual collision claim costs after the introduction of traffic calming measures. Of the 85 international case studies reviewed, the decrease in collision frequency ranged from 8 to 100%
4. The results of this research provide evidence that the safety benefits of traffic calming are both quantifiable and significant.

B. Literature on Land Development Patterns (Neotraditional Design Principles, Density, Land Use Mix, Regional Location, Site Design)

Corbett, J. and Joe Velasquez. 1994. *The Ahwahnee Principles: Toward more livable communities*. Sacramento, CA: Center for Livable Communities..

1. The Ahwahnee Principles were developed by a group of innovative architects and planners in response to the current state of our communities. The problems addressed by this group include increased traffic congestion and worsening air pollution, loss of open space, the need for costly infrastructure improvements, the inequitable distribution of economic resources, and a loss of a sense of community. The goal was to provide guidelines for the creation of more livable communities.
2. The Ahwahnee Principles were formulated by a group of architects in 1991 and were written as a set of guidelines to be used by local elected officials. These guidelines included community principles, regional principles, and an implementation strategy.
3. The Ahwahnee Principles are being implemented by cities and counties throughout the nation, with most activity occurring on the east and west coasts. The city of Cathedral City in California has adopted the Ahwahnee Principles by resolution and has started to incorporate them into its general plan. The federal government has also taken notice. A document called Vision/Reality produced by the U.S. Department of HUD for local government officials interested in applying for CDBG funds has incorporated the guidelines into its text.
4. The Ahwahnee Principles explains how over time, Americans love affair with the automobile has actually reduced our commuting options and hindered the freedom we associate with travel. This guide describes how we have designed towns that are unsafe and inaccessible to the pedestrian. We have separated uses, wasted undeveloped land, created homogenous business parks, and paved over acres of land. The authors present a different way of designing communities – compact, walkable communities that do not revolve around the automobile. The guide stresses that all parts of a community should be connected by streets or paths and that cul de sacs should be eliminated.

Crane, R. 1996. *Cars and Drivers in the New Suburbs: Linking Access to Travel in Neotraditional Planning*. *Journal of the American Planning Association* 62(1): 51-63.

1. This paper presents a theoretical argument to challenge the assumptions behind neotraditional design theory, specifically the assumption that a return to grid patterns will result in less driving.

2. Crane assesses the effect of improved access on travel distance, trip frequency, and mode split, where access is interpreted solely as a cost characteristic related to trip length, travel behavior is described by a microeconomic model of individual demand, and new suburban designs are assumed to reduce the distance required to make any trip.
3. All things considered, increased access, resulting in shorter distances, will induce people to take more trips. Even if pedestrian- and transit-oriented access improve the most, auto trips may not fall. The relative modal mix will depend on which modes fall faster, in terms of per-trip costs.
4. This study challenges the assumption that reducing distances between trip origins and destinations will increase walking and biking. The “cost” of making a trip will also fall for auto travel, increasing its desirability as well.

Crane, R. 1996. On Form versus Function: Will the New Urbanism Reduce Traffic, or Increase It? *Journal of Planning Education and Research* 15: 117-26.

1. This paper presents a formal argument to challenge the assumptions behind neo-traditional design theory. It utilizes concepts derived from microeconomics to assess the impact of grid street networks, traffic calming measures, and land use mixing on automobile travel.
2. Crane assesses the effects of grids, traffic calming, and land use mixing on number of car trips, VMT, and car mode split. A deductive analytical model is developed, derived from microeconomic theory. Travel and mode choice are seen through the prism of cost, where cost is seen as a composite variable including time and prices. The propensity to take trips by auto in redesigned neighborhoods are viewed as a function of absolute costs (cost per auto trip, regardless of costs for other modes) and relative costs (auto trip cost compared to trip costs of other modes).
3. A three-by-three matrix is developed, assessing the impact of the three neotraditional design variables on car trips, VMT, and car mode split. In sum, Crane’s theory predicts that the travel effects of neotraditional design are largely unknown: much of the impact will depend on which travel mode enjoys the largest reduction in costs.
4. This study challenges the assumption that neotraditional design will automatically decrease driving and increase walking and biking.

Moos, R., and P. Sommers. 1976. *The Architectural Environment: Physical Space and Building Design*. In R. Moos (Ed.), *The Human Context: Environmental Determinants of Behavior*. New York: Wiley & Sons.

1. The design of buildings and cities has an effect on the behavior of the people who live and work in them. This chapter discusses how human behavior is affected by the man-made physical environment that people occupy.
2. This literature review examines the effect of architectural design on specific behaviors. The authors frequently cite studies on suburbia to show how factors such as distance, design, spatial arrangement, and amenities affect the behaviors of its residents. The chapter also discusses the notion of congruence, meaning that the same environment may affect different people in vastly different ways.
3. Studies in real life and laboratory settings have conclusively shown how environments encourage behaviors with which they are congruent. With this knowledge, the authors recommend that the next logical step is to develop ways in which designers and architects can work with the end users more effectively to ensure that the results will be congruent with the users' goals.
4. This chapter provides a set of observations regarding the influence of the built environment in general, and of buildings in particular, on human psychology and behavior. The authors claim that we must become more aware of our environment and the reasons we make certain decisions. Moos and Sommers advocate the inclusion of the end-users in the design process through group planning.

Pedestrian Federation of America. 1995. *Walk Tall: A citizen's guide to walkable communities*. Washington, D.C.

1. This guide, produced by the Pedestrian Federation of America, includes stories, ideas, suggestions, and resources to help make communities more walkable.
2. This guide is full of walking statistics compiled from Pathways for People, the National Bicycling and Walking Study, the National Highway Traffic Safety Administration and 1000 Friends of Oregon among others. The intended audience for this publication is community or neighborhood organizations. It is not an academic piece but provides important statistics on walking.
3. This guide successfully sheds light on the lack of support that pedestrian planning has received. It describes the benefits of walking, gives examples of walkable communities, the obstacles that must be overcome, and most importantly the action that should be taken to make communities more walkable.

4. For our purposes, this guide has synthesized studies relating to physical activity and the benefits of walking to public health. It explains with a graphic that leading a sedentary lifestyle is the biggest contributor to heart disease in the U.S. The article lists the many health benefits associated with regular walking as well as the benefits experienced in the workplace. The article also mentions the current trends in urban and suburban developments and how they are not conducive to pedestrianism. The authors state that continuing to design communities that are inaccessible and unsafe for pedestrians has translated into increased health care costs for society and unnecessary illness for individuals. “Walk Tall” also points out the importance of environmental factors that influence travel behavior, citing the LUTRAQ research. It provides an aerial photo of two communities, one designed as a grid and the other built with cul-de-sacs. This graphic highlights the need for continuity in sidewalks.

Southworth, M. 1997. Walkable Suburbs? An Evaluation of Neotraditional Communities at the Urban Edge. *Journal of the American Planning Association* 63(1): 28-44.

1. This study was conducted to compare the design characteristics of two recently-constructed prototype neo-traditional communities with a traditional turn-of-the-century streetcar suburb and conventional late-twentieth-century suburbs.
2. The author qualitatively assesses the similarities and differences between these three types of communities in terms of patterns of built form, land use, public open space, street design and circulation, and pedestrian access.
3. The author concludes that while the neo-traditional communities mimic traditional designs, the models built to date are sanitized versions of the small town, excluding much of what it takes to make a metropolitan region work. These suburbs systematically exclude housing for poorer residents, commercial and industrial space, cemeteries, waste disposal sites, and other uses.
4. This study is a good summary of built examples of neo-traditional design. It points out both the strengths and weaknesses of communities that have been built under this paradigm to date.

Southworth, M. and P. Owens. 1993. The Evolving Metropolis: Studies of Community, Neighborhood, and Street Form at the Urban Edge. *Journal of the American Planning Association* 59(3): 271-87.

1. This paper examines the form of the metropolitan fringe over time. It was written to assess the ways in which neighborhoods, communities, streets, and lots have changed in practice in the San Francisco Bay area.

2. This study utilizes the comparative case study method to identify trends in urban fringe development. The study identifies spatial typologies and analyzes patterns of growth, land use, and street layouts for several periods of suburban development beginning in the early twentieth century. Typologies are identified and discussed for community street patterns, growth patterns, and land use patterns, neighborhood street patterns, street scale, lot size and shape, and building pattern.
3. Several generalizable patterns of urban fringe development are discussed. The urban edge is more fragmented now; as economic functions have dispersed over the century, a polycentric pattern of urban development has emerged. There has been a steady outward diffusion of low-density development patterns. There has been an increased separation of uses within communities, increasing circulation routes between different zones. There has been an increasing lack of attention to and investment in public spaces and structures, in particular streets and parks. There has been a trend toward larger units of development within the single-use zones. Finally, urbanization has been increasingly indifferent to the natural, cultural, and historic landscape.
4. This study provides a useful discussion of changes in community and neighborhood design in the United States over the course of the twentieth century. It also provides useful typologies for street networks, street design, community growth and dispersal patterns, and neighborhood design.

Transport Concepts. 1994. *Linkages: Built Environment, Well Being, and Active Living*. Prepared for Active Living and the Environment Program, Fitness Canada.

1. This report summarizes arguments for improving the built environment in order to improve physical activity.
2. This study summarizes trends in built form in Canada, in physical activity patterns, and in the state of research in to linkages between them. The study presents some useful descriptive statistics comparing modal choices with urban form variables in Ottawa.
3. This is a summary report from a walking and bicycling advocacy group.
4. This study is a short, useful summary of the linkages between urban form and physical activity. There is no original research.

C. Empirical Literature on Relationships Between Urban Form and Travel Behavior

Apogee/Hagler Bailly. 1998. *The Effects of Urban Form on Travel and Emissions: A Review and Synthesis of the Literature*. Prepared for U.S. Environmental Protection Agency, Urban and Economic Development Division. Washington, D.C.

1. This report provides a review and analysis of literature on the connection between land use measures and travel by motor vehicles, transit, and by non-motorized modes.
2. This study is an exhaustive review of transportation literature.
3. This study organizes and critiques an extensive body of literature. Two types of studies are reviewed, empirical studies and simulation studies, regarding the impact of urban design variables on travel patterns. The study concludes that the literature demonstrates the existence of a relationship between urban form and travel behavior. Methodological challenges to research in this area are discussed at length.
4. This study provides an exhaustive summary and critique of the literature regarding the relationship between urban form and motorized travel. The sections that cover the literature on motorized travel are excellent. While there is some discussion of the impact of urban form on non-motorized travel, the study is not as useful in this area.

Berman, M.A. 1996. The transportation effects of neo-traditional development. *Journal of Planning Literature* 10(4): 347-63.

1. Proponents of neo-traditional development claim that these types of communities will solve many of the problems currently plaguing suburban areas. This type of development emphasizes a return to the grid patterns and walkable streets of the early part of this century. Many believe that it will lead to increased walking and decreased driving.
2. This article reviews the literature relevant to neo-traditional development's effects on transportation. The central notion behind neo-traditional design is that the physical layout serves as an environmental determinant in shaping people's behavior. This review focuses on whether neo-traditional development can reduce automobile use and increase walking. The article briefly discusses the differences between neo-traditional and conventional suburban development. It then reviews general trends and characteristics of travel behavior to provide a background for analyzing the transportation behavior claims that neo-traditional development's proponents make. Next, it attempts to determine what the transportation effects will be and the effect the traditional grid may have on driving.

3. The review found that neo-traditional developments will reduce driving significantly only if they provide levels of access that are comparable with existing suburban access. This will require that people live in neo-traditional developments, that a wide range of activities is within walking distance, and that people choose not to drive. The greatest effects can be expected for shopping trips in areas where there are few available shopping centers and for other nonwork trips that can be accomplished on foot in neo-traditional developments. The grid pattern found in neo-traditional developments may reduce congestion on main streets and may reduce automobile travel times.
4. While this type of development has the potential to increase the amount of walking, much of the arguments are not empirically based. A truly walkable community relies on a number of factors to make it work; location of retail, lack of proximity of other retail centers, nearby residences, profitability of central retail, and commercial establishments oriented to the pedestrian. Thus, neo-traditional development may provide an opportunity to increase physical activity through increased walking but this is not assured simple by building a grid layout with sidewalks.

Cervero, R. 1988. Land-Use Mixing and Suburban Mobility. *Transportation Quarterly* 42(3): 429-46.

1. This article examines the potential mobility benefits of developing mixed-use suburban workplaces. The effects of current land-use mixes on the commuting choices of suburban workers are also studied based on an empirical analysis of large suburban centers in the U.S.
2. This article is split into three parts. The first discusses the mobility benefits of mixed-use suburban office development. In this section, an argument is advanced by way of published source material. The second summarizes the land use composition of suburban office centers as of the late 1980s. In this section, the author relies on data gathered in 1987 on the land-use activities of 57 of the largest suburban centers in the U.S. The third section utilizes stepwise regression techniques to study the effects of suburban land-use mixes on mode choice
3. The review of 57 suburban office centers found that some 59% of all floorspace is devoted to office space; only 15% is retail and 10% residential. Cervero asserts that increases in the mixture of uses at suburban office centers would result in fewer employee trips by automobile during the workday, would spread out trips more evenly during the day instead of crowding the majority into the lunch hour, and would induce ridesharing and shared-parking possibilities. The results of the regression analyses suggested that single-use office settings induced solo commuting, whereas mixed-use settings generally were found to encourage more ridesharing, walking, and cycling.

4. This analysis is one of a small number addressing the topic of mixing uses within office complexes themselves. It provides empirical support to the idea that mixed use development in suburban office complexes can reduce traffic congestion and increase the number of trips made during the workday that are by foot.

Cervero, R. Congestion Relief: The Land Use Alternative. *Journal of Planning Education and Research* 10: 119-29.

1. This paper argues that coordinated land use planning can provide lasting mobility benefits over the long run. Four initiatives are proposed.
2. The author presents and discusses the merits of four land use initiatives that could provide mobility benefits: densification, mixed-use development, jobs-housing balance, and pedestrian-friendly site design.
3. The author argues that in the absence of congestion pricing, these four urban form variables will be critical in maintaining mobility in coming decades.
4. This study utilizes previous research and the author's own scholarly insights to advocate the adoption of higher density levels, mixed-use development, a greater balance of jobs with housing, and pedestrian-friendly design.

Cervero, R. 1986. *Suburban Gridlock*. New Brunswick, N.J.: Center for Urban Policy Research.

1. This book centers on the boom in suburban office development during the 1980s, and the mobility implications this entailed.
2. The author's primary method is discursive, defining problems, analyzing their significance, and suggesting solutions. Some original data is presented, with most being descriptive. Some statistical analysis is conducted. The author also discusses design issues using maps and photographs.
3. The author traces the growth in suburban office development and resulting congestion problems. Congestion is seen as the result of improper suburban office design and inadequate suburban traffic management. Cervero calls for parking reform, greater jobs-housing balance, expanded transit options, and traffic demand management.
4. The chapter on suburban office design is the most useful for understanding how built form can encourage or discourage physical activity.

Cervero, R., and R. Gorham. 1995. *Commuting in Transit versus Automobile Neighborhoods*. *APA Journal*: 210-25.

1. This article compares commuting characteristics of transit-oriented and auto-oriented suburban neighborhoods in the San Francisco Bay Area and in Southern California.
2. The authors matched neighborhoods based on urban form characteristics. Transit-oriented neighborhoods were defined as having been initially built along a streetcar line, having grid street networks, and built largely before World War II. Auto-oriented neighborhoods were built after World War II, have random street patterns, laid out without regard to transit, and have lower density levels. Income levels were similar across neighborhood types, and matched pairs were no more than 4 miles from one another. Drive-alone %, Transit %, and Pedestrian % were compared.
3. Transit neighborhoods averaged higher walking and bicycling shares, particularly in the San Francisco Bay Area. Weaker relationships between form and nonmotorized travel in the Southern California communities led the authors to hypothesize that regional form – particularly the massive amount of highways – may overwhelm neighborhood design in influencing nonmotorized travel.
4. This study provides support for the hypothesis that urban form impacts physical activity. This study is particularly interesting in that its design controlled for regional location and income.

Cervero, R. and C. Radisch. 1995. *Travel Choices in Pedestrian versus Automobile Oriented Neighborhoods*. Working Paper 644. University of California at Berkeley. Berkeley, CA: Institute of Urban and Regional Development.

1. This paper investigates the effects of New Urbanism design principles on both non-work and commuting travel by comparing modal splits between different neighborhoods in the San Francisco Bay Area.
2. Two communities were selected for analysis based on variations in urban form. One neighborhood was neo-traditional, one was standard suburban. Two separate surveys – one for work trips and one for non-work trips – were sent to randomly selected households in these communities. Data were matched to neighborhoods and compared.
3. Residents of the neo-traditional community averaged 10% more non-work trips by non-automobile modes, after controlling for factors like income and transit service levels. For work trips, modal splits were more similar.
4. This study provides support for the hypothesis that urban form impacts physical activity, even after controlling for socioeconomic variables.

Dunphy, R., and K. Fisher. 1994. Transportation, Congestion, and Density: New Insights. *Transportation Research Record 1552: 89-96.*

1. This study assesses density and its the relationship to driving, transit use, urban form, and congestion.
2. Analyses using 1990 NPTS data were made for both regional and national travel patterns. Descriptive statistics were used.
3. The study confirms patterns found by other researchers of higher levels of transit use and lower automobile travel in higher-density communities. Rates of walking and bicycling also become significant at higher density levels. However, the pattern is not clear-cut because of the intervening relationship between density and the demographic characteristics of households. Households in high-density areas appear to have lower travel needs in the first place. Increasing density of housing and employment levels will improve transit use only at high levels.
4. This study provides support for the general hypothesis that density impacts travel patterns, but that density is insufficient for explaining travel behavior.

Ewing, R., Haliyur, P., and G. Page. 1994. Getting Around a Traditional City, a Suburban Planned Unit Development, and Everything in Between. *Transportation Research Record 1466: 53-62.*

1. This study was conducted to better understand effect of location and land use on travel patterns in six communities in Palm Beach, Florida.
2. Six communities were selected for study based on variations in street networks, regional location, and land use mix. Household travel data were tested for statistically significant differences in trip frequency, chaining, length, and overall vehicle hours of travel.
3. Households in standard suburbs generated almost two-thirds more vehicle hours of travel per person than comparable households in traditional communities. The former partially make up for this by doing more trip chaining. Communities should internalize as many facilities and services as possible, by concentrating them in centers and corridors.
4. This study provides support for the general hypothesis that urban form impacts transportation patterns, including vehicle trip frequency and degree of automobile use.

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

1. This study was undertaken to test the impact of land-use mix, population density, and employment density on travel by single-occupant vehicle, transit, and walking for both work and shopping trips.
2. A database was developed with a comprehensive set of variables for which density may be a proxy. This analysis employed a correlational research design in which mode choice was compared among census tracts with differing levels of density and mix. Urban form variables were gross population density, gross employment density, and land-use mix.
3. Findings indicated that both density and mix are related to mode choice, even when controlling for non-urban form factors for both work and shopping trips. The relationship between population and employment density and mode choice for single occupancy vehicle, transit, and walking is nonlinear for both work and shopping trips. Transit use and walking increase as density and mix increase, and single-occupant vehicle usage declines.
4. This study provides empirical support for the proposition that two basic urban form variables, density and mixture of land uses, impact the propensity to walk.

Frank, L., Stone, B., and W. Bachman. 1999. Linking Land Use with Household Vehicle Emissions in the Central Puget Sound: Methodological Framework and Findings. *Transportation Research D (forthcoming).*

1. This study assesses the impact of various land development, transportation system, and demographic variables to understand emissions in the Puget Sound area.
2. The authors gathered two sets of variables: land use data, including household and employment density, distance to work, and census block density (a measure of street connectivity); and travel survey data from a transportation panel survey in the Puget Sound area. Pollutant emissions are estimated from the transportation data and matched to the urban form variables. Cross-tabulations and regression analyses are utilized.
3. Statistical analyses showed that a significant inverse relationship exists between household density, work tract employment density, and street connectivity, with vehicle emissions. These effects were significant while controlling for income, household size, vehicle ownership, and income.

4. This study provides statistical evidence supporting the existence of a relationship between urban form and emissions levels, while controlling for socioeconomic and demographic variables. Nonmotorized transportation is not addressed.

Friedman, B., Gordon, S., and J. Peers. 1994. Effect of Neotraditional Neighborhood Design on Travel Characteristics. *Transportation Research Record 1466*: 63-70.

1. This study used data from a 1980 regional travel survey of San Francisco Bay Area households to see if residents of traditional (pre-World War II) and suburban (post-World War II) residential developments exhibited differing travel habits.
2. The authors drew travel data for residents of standard suburban and traditional communities, where the former were selected based on having been developed since World War II, having hierarchical road networks, limited access points, and low levels of transit service. Travel patterns were compared using simple percentages. Income was not controlled for.
3. Households in the standard suburban communities used vehicles more. Households in the traditional neighborhoods used transit twice as often, bicycled twice as often, and traveled by foot 50% more often.
4. This study provides support for the hypothesis that urban form impacts nonmotorized travel patterns. The study did not control for demographic and socioeconomic variables.

Gordon, P., and H.W. Richardson. 1989. Gasoline Consumption and Cities: A Reply. *Journal of the American Planning Association 55*(3): 342-6.

1. This article was written in response to Newman and Kenworthy's "Gasoline Consumption and Cities," which appeared in the Winter 1989 issue of the *Journal of the American Planning Association*. In this article, Gordon and Richardson seek to repudiate many of the points made by Newman and Kenworthy that residents of compact cities consume less gasoline per capita, an indicator of vehicle miles of travel, compared to residents of lower-density cities.
2. This is an issue-oriented paper. It critiques the analysis, methodology, and policy and planning prescriptions of Newman and Kenworthy's study. They utilize previous research to substantiate rebuttals to Newman and Kenworthy's study in five areas: they question whether it makes sense to rely upon fuel use minimization as the indicator of good urban form; they question the validity of the global comparisons made by Newman and Kenworthy; they question whether it makes sense to advocate urban centralization in the face of the co-location of employment and housing at the

urban fringe; they question whether rail transit has the potential for moving commuters in the U.S. that Newman and Kenworthy say it does; they question the land value benefits of transit development.

3. This paper presents one critique of many of the seminal article written by Newman and Kenworthy in 1989. Gordon and Richardson assert that the empirical study by Newman and Kenworthy was analytically and methodologically unsound. They assert, among many other things, that Newman and Kenworthy overstate both the feasibility and desirability of transit-oriented development, that it is unsound public policy to limit gasoline consumption, that there are more efficient ways to limit gasoline consumption than changing land use patterns (e.g., higher fuel taxes), and that decentralized development has proven to be more economically sound than centralized development for American cities.
4. This article provides a good example of the arguments utilized by defenders of low-density suburban development in the United States. This article should be read in conjunction with Newman and Kenworthy's.

Handy, S. 1996. Understanding the Link Between Urban Form and Nonwork Travel Behavior. *Journal of Planning Education and Research* 15: 183-98.

1. This paper presents one framework for researching the link between urban form and travel behavior. The author attempts to generate a methodology for disentangling the effects of different urban form variables on travel behavior.
2. Four neighborhoods in the San Francisco Bay Area were selected as case studies, using three criteria: accessibility to regional centers of activity, street network design, and socioeconomic characteristics. The first two were allowed to vary, the third was controlled for as much as possible. A travel survey was conducted of residents in these neighborhoods, generating data for local and regional nonwork trips. Descriptive and inferential data are presented.
3. Handy finds that urban form does make a difference in determining whether people perceive walking as an option available to them. To encourage walking, the distance between residential and commercial areas needs to be short, barriers such as major arterials should not be present, and commercial areas need to be designed for pedestrian access. However, she stresses that the better and more numerous the destination and modal choices, the less the impact of providing a new choice, such as improving conditions for pedestrians. Additionally, the regional context – the proximity and mix of regional retail and commercial destinations – will moderate the effectiveness of neighborhood land use policies.
4. This article finds evidence to support the proposition that urban form does affect the propensity to walk. It also provides a very useful discussion of the difficulties inherent

in attempting to understand the relationships between travel behavior and land use configurations.

Handy, S. 1992. Regional Versus Local Accessibility: Neo-Traditional Development and its Implications for Non-work Travel. *Built Environment* 18(4): 253-67.

1. This study focuses on how variations in regional location and neighborhood design characteristics impact the propensity to make walk trips.
2. Four communities in California were selected and paired based on accessibility of the community to major regional shopping centers, the relative presence or absence of retail and service centers within the boundaries of the local community, and the type of street network. Handy was able to select four cases sufficient to fill a two-by-two matrix, with “local accessibility” (presence or absence of local retail and service centers; type of street network) forming one axis and “regional accessibility” (availability of large retail outlets in the region). Handy selected neighborhoods that were similar in residents’ socioeconomic characteristics.
3. Residents of the two neighborhoods with traditional design characteristics made more utilitarian walk trips than residents of the two more modern neighborhoods. The number of recreational walk trips was about the same across all four neighborhoods. Regional location made some difference. In the high regional accessibility area, local trips did not seem to replace trips to regional shopping centers, while in the low regional accessibility area, they may have to some extent. The evidence here was mixed.
4. This study supports the proposition that local design conditions influence physical activity patterns. The study’s conclusions regarding the effects of large regional retail centers are more mixed.

Holtzclaw, J. 1994. *Using Residential Patterns and Transit to Decrease Auto Dependence and Costs*. Prepared for National Resources Defense Council for California Home Energy Efficiency Rating Systems.

1. This study attempts to measure reductions in automobile usage and personal transportation costs that result from neighborhood characteristics.
2. Motor vehicle usage per household (autos/HH) and vehicle miles traveled (VMT) are modeled as influenced by residential density, transit accessibility, neighborhood shopping characteristics, and pedestrian amenities. 28 communities in California were selected for study. VMT was calculated using smog check data. Data for autos/HH were gathered using census data. A series of regressions were run to obtain the best models for the influence of neighborhood form on VMT and autos/HH.

3. The only significant variables were density and transit accessibility; adding other variables or replacing these variables with others did not explain VMT or autos/HH better than these two alone.
4. The study suggests that, amongst urban form variables, a combination of high density and transit service levels are the most important in influencing driving decisions. The authors did not attempt to analyze nonmotorized travel patterns.

Kockelman, K. 1997. *Travel Behavior as a Function of Accessibility, Land Use Mixing, and Land Use Balance: Evidence from the San Francisco Bay Area*. Submission to the 76th Annual Meeting of the Transportation Research Board. As summarized in Apogee (1998).

1. The author tests the effects of land use factors on total vehicle miles of travel (VMT) per household, non-work home based VMT per household, auto-ownership, personal vehicle mode choice, and walk/bike mode choice.
2. The study uses regression analysis to determine influence of land use on VMT. The study accounts for a large variety of urban form and non-urban form variables (e.g., household size, income, gender, etc.).
3. This study finds that increasing the accessibility to jobs and the general mix of land uses reduces vehicle ownership, all other factors equal. A doubling in accessibility reduces vehicle ownership by 7.5%. Accessibility to employment is important in influencing mode choice. Local land use mix is not important in mode choice, after the effect on vehicle ownership is considered. Since land use mix is found to affect VMT but not mode, this finding suggests that mixed use areas have shorter trip lengths. Density does not prove to be significant in the VMT models. Land use mixing and accessibility appear to be the most important land use factors.
4. This study provides a statistical analysis of the relationship between urban form and non-urban form variables on the one hand and VMT and mode choice on the other. Its findings are mixed. VMT is found to be influenced by land use mixing and accessibility to employment but mode choice is not.

Moudon, A.V., Hess, P., Synder, M.C., Stanilov, K. 1997. *Effects of site design on pedestrian travel in mixed-use, medium density environments*. Report No. WA-RD 432.1, Washington State Transportation Center.

1. Moudon and colleagues have attempted to better understand if there is any relationship between pedestrian traffic and site design.

2. The authors employed a quasi-experimental, cross-sectional survey method to study 12 neighborhood sites with commercial centers in the Puget Sound region. In assessing any relationships, four variables were controlled for; population density, income, land use type and mix, and a one-half mile radius area within which all of the other variables are spatially contained. Half of the sites selected were thought to have site designs conducive to pedestrian travel, and the other half of the sites did not. Small blocks and continuous and connected sidewalks were site design characteristics thought to promote walking.
3. Moudon et al did indeed find that pedestrian volumes are related to site and pedestrian facility design. The three conventional measures used to predict pedestrian travel – population density, income, and land use distribution and intensity - are individually and together, insufficient to explain pedestrian volumes. This study found that site design (block size and availability of pedestrian facilities) must also be considered.
4. This study reveals that most of the barriers to increased walking occur in suburban areas. To increase pedestrian volumes in suburban locations it is recommended that additional pedestrian infrastructure be provided and pedestrian safety issues be addressed. The provision of additional facilities for walking may also decrease auto congestion by encouraging people to substitute walk trips for auto trips. It also recommends that pedestrian facilities make connections around transit centers, retail areas, and schools.

Nelson, A.C. and Allen, D. 1997. If you build them, commuters will use them: Association between bicycle facilities and bicycle commuting. *Transportation Research Record 1578: 79-82.*

1. Many planners and bicycling proponents believe that if bicycle pathways are provided, people will use them. This belief has not been formally supported by significant cross-sectional research, only anecdotes and a few case studies. This study attempts to use a cross-sectional analysis to show an association between bicycle pathway provision and commuting by bicycle after controlling for a variety of variables.
2. This study of 18 U.S. cities uses data obtained from a previous study by Goldsmith. It takes into account mean high temperature, terrain, and mile of bikeways per 100,000 residents. The regression equation uses mean high temperature, number of rain days, a binary variable indicating the flatness of terrain, percent of students, and bicycle pathway miles per 100,000 residents.
3. The results of the regression analysis show that the rate of commuters using bicycles in their journey-to-work ranges from a low of .16 percent in Dallas to a high of 7.34 percent in Boulder. The coefficient suggests that each mile of bikeway per 100,000 residents is associated with a .075 percent increase in commuters using bicycles. This supports the theorized association, but the authors state that much more work needs to be done to conclusively support these findings.

4. These results can not be interpreted as cause-and-effects, merely statistical associations. More rigorous analysis is needed that would take into consideration long-term effects, using a larger dataset, and testing for before and after effects. However, these findings do suggest that there is latent demand for bicycle facilities that can only be tapped by providing bicycle facilities. It can also be inferred that providing bicycle facilities on-street may be more effective than a grade-separated path for bicycle journey-to-work commuting.

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

1. This study was conducted to understand the influence of density on gasoline consumption in a sample of cities from the U.S. and around the world.
2. Gasoline consumption per capita was measured and compared in ten large U.S. and 32 global cities. Consumption was compared for the sample of U.S. cities and for the sample of global cities against various measures of density, proportion of population in city center, proportion of city's jobs in urban center, and transit use.
3. The study's main finding was the population and job density are the key land use parameters in influencing gasoline consumption. The low-consumption cities were those with a dense form, a strong center, and intensively utilized suburbs that provide the backbone for transit and more walking and biking.
4. This study provides support for the hypothesis that density impacts travel behavior.

Parsons, Brinkerhoff Quade and Douglas, Inc., Cambridge Systematics, Inc., and Calthorpe Associates. 1996. *Transit, Urban Form and the Built Environment: A Summary of Knowledge*. Prepared for Transit Cooperative Research Program, Transportation Research Board.

1. The purpose of this report is to synthesize the findings and conclusions of TCRP Project H-1 with a large body of literature described in literature review "TCRP Research Results Digest, No. 7, June 1995." Research for project H-1 focused on how urban form influences transit demand, how the built environment near rail transit stations affected the mode of access and the size of the catchment area, whether neighborhood land use mix and urban design influences the demand for transit, and how transit influences land uses.

2. This report is a literature review, focusing on the influence of land use on transit patronage, and on transit's influence on urban form. Data from previously published studies is provided, as are a large number of charts and graphs.
3. The most relevant sections of this report address the influence of density and land use mix on transit patronage. According to the summary of studies reviewed for this report, the density of transit corridors strongly influences transit ridership; the effects of density are correlated with employment center size, corridor level urban structure, transit service characteristics, and the supply and price of parking; and residential density thresholds are meaningful only if considered in conjunction with the cost and efficiency of service. Land use mix influences work trip and midday mode choice decisions in employment centers. Land use mix in neighborhoods induces transit use, though its effects are less influential than density. Land use mix has special importance for users of non-motorized modes. Transit supportive design in neighborhoods supports transit as well as non-motorized modes. Finally, it is difficult to disentangle the effects of land use mix and urban design from the effects of density.
4. This is a thorough review of the literature regarding urban form and transit usage. Its most useful section discusses the relationships between density, land use, and transit patronage. Within this section, the report discusses how transit-supportive urban design also supports walking.

Parsons Brinckerhoff Quade and Douglas Inc. 1993. *The Pedestrian Environment: Volume 4A*. Portland, OR: 1000 Friends of Oregon.

1. This report analyzes the connection between land use patterns and household travel behavior in the Portland, Oregon area. Data from travel surveys and forecasting models was used to test the hypothesis that travel behavior is affected by neighborhood land use patterns. An index variable was constructed to measure the quality of the pedestrian environment.
2. This study examines and quantifies the relationships between household travel mode choices and the quality of the pedestrian environment, residential density, transit level-of-service, and proximity to employment activity. The quality of the pedestrian environment is captured through the construction of a "pedestrian environment factor" (PEF) index variable. A multiple regression model is also constructed to explain both household VMT and vehicle trips generated.
3. The results of simple correlations show that residents in neighborhoods with higher density, proximity to employment, grid street patterns, sidewalk continuity, and ease of street crossings tend to make more pedestrian and transit trips, whereas residents of more distant, lower density suburban areas with auto-oriented land use patterns show extensive reliance on automobiles. Multiple regression models show that the land use

related variables, including the PEF, significantly impact both household VMT and the number of vehicle trips.

4. This study provides one of a few quantified, statistically rigorous research designs that attempts to discover whether the quality of the pedestrian environment actually increases the level of walking. Its conclusions supports the hypothesis that pedestrian-friendly design features such as sidewalk continuity, ease of street crossings, and gridlike street patterns encourage walking.

Parsons, Brinckerhoff Quade and Douglas, Inc., Cambridge Systematics, Inc., and Calthorpe Associates. 1993. *Building Orientation: A Supplement to The Pedestrian Environment: Volume 4B*. Portland, OR: 1000 Friends of Oregon.

1. This report focuses on the setback and building orientation of commercial structures, as these features influence household vehicle miles of travel (VMT). Travel behavior of households in the Portland, Oregon metropolitan area are compared in this study to building setback and orientation. It is hypothesized that neighborhoods with shallower setbacks, indicating older building structures, will induce more walking and bicycling.
2. Researchers assumed that structures built before about 1950 were built in an era in which walking and public transit played important roles in urban mobility. An index variable was constructed to establish the proportion of buildings in each of the region's 400 traffic analysis zones built during or before 1950. This data was first matched to modal share data for each zone. This variable was also used in a multiple regression equation, where VMT was the dependent variable and a series of socioeconomic and other urban form variables were introduced as controls.
3. The results suggest that building setback and orientation plays some role in influencing travel mode share and VMT. For zones with 0% share of buildings built before 1951, nearly 94% of travel was by auto and only 1.9% walk/bicycle. For zones with 81-100% share, those figures were 82.5% and 5.3% respectively. Additionally, after controlling for socioeconomic variables and other urban form variables such as population density and land use mix, building orientation and setback had a statistically significant influence on VMT.
4. This review is unique in attempting to address the impact of building orientation and setback on travel behavior. While it is frequently hypothesized that this variable influences travel, there are almost no studies that attempt empirical testing. This study lends some evidence in support of the hypothesis.

Pucher, J. 1997. *Bicycling boom in Germany: A revival engineered by public policy*. *Transportation Quarterly* 51(4): 31-46.

1. In this article, Pucher explores the dramatic increase in bicycle use in German cities over the last two decades. He notes that the share of trips in urban areas taken by bicycle in western Germany rose by 50% from 1972 to 1995. This has occurred in spite of rapid suburbanization, rising auto ownership, increasing trip lengths, and rising per capita incomes. Pucher attempts to show that other countries and cities can achieve similar results with the right combination of policies.
2. Pucher presents data collected from a number of German cities regarding modal split and travel mode trends. He also extensively researched and presented the policies that made the dramatic increases in cycling occur.
3. The author found that the bicycling boom in German cities is almost entirely due to public policies that have greatly enhanced the safety, speed, and convenience of bicycling while making auto use more difficult and expensive. The author states that the differences in bicycling use between the U.S. and Germany cannot be explained by such factors as climate and topography, lack of alternatives, economic necessity, or trip distances. One possible explanation, however, is the relative price of gasoline.
4. This article suggests that the correct combination of public policies to encourage convenient and safe bicycle use while discouraging automobile use can be effective for increasing bicycle usage, even in the U.S. Presumably, these policies will also increase the promotion and participation in physical activity through the increases in human powered transportation.

Replogle, M. 1995. *Integrating Pedestrian and Bicycle Factors into Regional Transportation Planning Models: Summary of the State-of-the-Art and Suggested Steps Forward*. Washington, D.C.: Environmental Defense Fund.

1. This study reviews typical techniques used in estimating the travel behavior effects of bicycle and pedestrian facilities and programs on emissions. It argues that current modeling techniques underestimate the influence of such facilities and programs on emissions.
2. The author reviews the most common techniques used to model emissions in the United States – regression analysis, market-share diversion analysis, and discrete choice analysis. Examples of techniques that have had some success in capturing these effects are presented. The author also reviews evidence to suggest that the dominant models fail in their assessment of the effects of slowing vehicle speed.
3. The author finds that most techniques that rely on aggregate data are incapable of capturing the emissions impacts of micro-scale alterations to urbanized areas. He also asserts that current models fail in their specification of the relationship between vehicle speed and emissions. Evidence from European traffic-calming measures suggests that

these measures not only increase pedestrian and bicycling traffic but also reduce emissions through reductions in speed, a finding contrary to dominant assumptions contained in U.S. models. The author calls for increased data-gathering on pedestrians and bicyclists and better models.

4. This study offers support to the idea that current air quality modeling techniques grossly underestimate the influence of pedestrian and bicycling travel, due to the models' assumptions and methodologies.

Shriver, K. 1997. Influence of environmental design on pedestrian travel behavior in four Austin neighborhoods. *Transportation Research Record 1578*: 64-75.

1. This study reacts to the scarcity of studies designed to better understand the underlying characteristics of a walkable neighborhood and the nontransport benefits of walkable neighborhoods. The results of this study are geared toward affecting public policies and programs developed to meet the recommended national policy goals of increasing nonmotorized trips from 8% to 15%.
2. In order to better understand the aspects of the physical environment that constrain or facilitate walking, a survey of four Austin neighborhoods was employed. These neighborhoods were characterized by their transportation infrastructure, development patterns, and design features. The data collected was used to compare the influence of the alternate urban forms on significant walk activity and attitudinal differences. The two pairs of neighborhoods chosen had contrasting transportation, land use, and design characteristics but similar density, housing, and population characteristics to control for differences in the socioeconomic status of the survey participants.
3. Shriver found that in two traditional neighborhoods, walking occurred with greater frequency, were predominantly short, involved secondary activities, and were generally utilitarian in nature. Walk trips in the modern, car-oriented neighborhoods were characterized by longer, less frequent recreational walks that involved fewer secondary activities. These results support the conclusion that neighborhood transportation, land use, and urban design characteristics influence walk distance, duration, purpose, and number of secondary activities. Another interesting conclusion was that those in the modern car-oriented neighborhood saw walkway continuity and trees as important environmental attributes with the trip purpose being the maintenance of health.
4. The results of this study suggest that traditional neighborhoods that allow for greater pedestrian movement may do more to promote a physically active lifestyle than the modern, car-oriented neighborhoods. However, this study does not conclusively prove this. Other factors must be analyzed such as levels and effects on health of auto emissions in each type of neighborhood, availability and participation in recreational facilities, and whether the residents of traditional neighborhoods have self-selected that particular environment.

Snellen, D., Borgers, A., and H. Timmermans. *The Relationship Between Urban Form and Activity Patterns: Preliminary Conclusions from an Activity Survey.* Paper presented at the European Transport Conference, Loughborough, UK, September 1998.

1. This study was conducted to better understand effect of urban form on travel patterns in Dutch cities and neighborhoods.
2. Activity diary administered to 586 respondents in 9 Dutch cities and 19 Dutch neighborhoods. Cities varied by type of road network and other urban form variables; neighborhoods varied by type of local road network, regional location, density, and amenities. Statistical methods were applied, including chi-square and ANOVA.
3. Mode choice and travel time for both work trips and shopping trips were significantly related to urban form variables. Grid street networks were consistently found to be important in inducing nonmotorized travel.
4. This study provides support for the general hypothesis that urban form impacts physical activity.

Steiner, R. 1994. Residential Density and Travel Patterns: Review of the Literature. *Transportation Research Record 1466: 37-43.*

1. This study is a review of the literature on the interactions between the household in high-density residential areas, the land-use characteristics of the area, and the transportation choices of households.
2. The review presents studies of the relationship between residential density and travel patterns or energy use, between density and the spatial distribution of activities, and between socioeconomic and demographic patterns of households and their travel patterns.
3. While the literature supports the existence of a general relationship between residential density and travel, including nonmotorized travel, studies often have not separated out other factors, including income, household size, life-cycle characteristics, and other land-use characteristics for which density may be a proxy.
4. This study is important in drawing attention to the shortcomings of the research on density and travel. While density may be very important, other urban form and non-urban form variables must be considered in future research.