

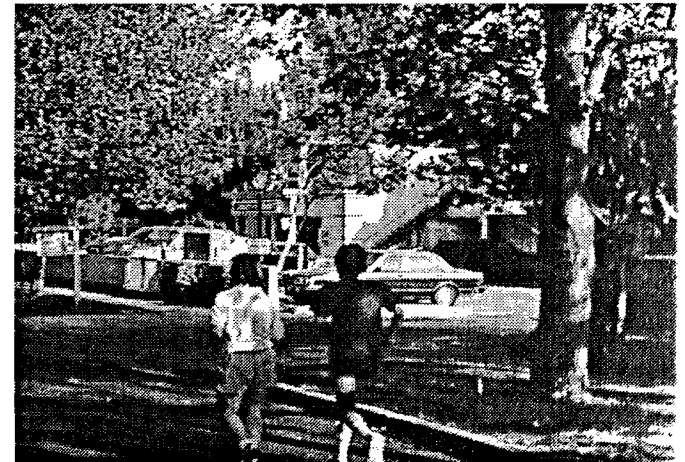
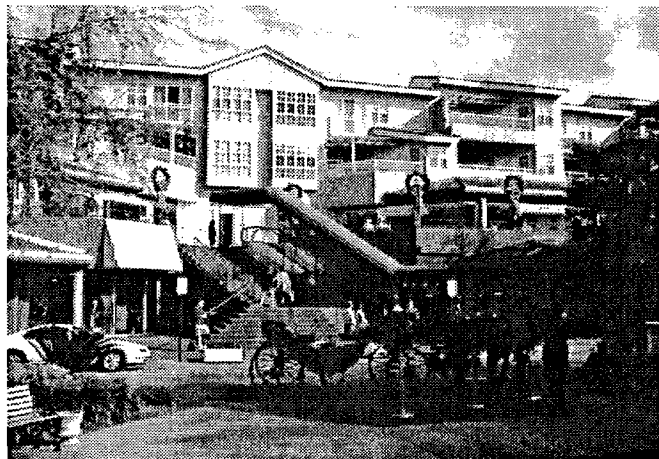
PEDESTRIAN- AND TRANSIT-FRIENDLY DESIGN

Reid Ewing

Joint Center for Environmental and Urban Problems

Florida Atlantic University/Florida International University

Prepared for the Public Transit Office,
Florida Department of Transportation
March 1996





CONTENTS

Acknowledgments	iv
I. Introduction	I
There is Hope!	
Sources	
Urban Design Literature	
Transit-Oriented Design Manuals	
Our Own Empirical Studies	
II. Checklist of Pedestrian- and Transit-Friendly Features	5
Essentials	5
Medium-to-High Densities	
Mix of Land Uses	
Short-to-Medium Length Blocks	
Transit Routes Every Half-Mile	
Two- or Four-Lane Streets (with Rare Exceptions)	
Continuous Sidewalks Wide Enough for Couples	
Safe Crossings	
Appropriate Buffering from Traffic	
Street-Oriented Buildings	
Comfortable and Safe Places to Wait	
Highly Desirables	31
Supportive Commercial Uses	
Grid-like Street Networks	
Traffic Calming Along Access Routes	

Closely Spaced Shade Trees Along Access Routes	
Not Much "Dead" Space (or Visible Parking)	
Nearby Parks and Other Public Spaces	
Small-Scale Buildings (or Articulated Larger Ones)	
Classy Looking Transit Facilities	
Nice Additions	47
"Streetwalls"	
Functional Street Furniture	
Coherent, Small-Scale Signage	
Special Pavement	
Lovable Objects, Especially Public Art	
APPENDIX A – Visual Preference Survey - Bus Stop Features	61
APPENDIX B – Mode Share Analysis - Land Use Influences	71
APPENDIX C – Ridership Analysis - Urban Design Factors	83

Acknowledgments

Contributors to this manual, most of them graduate students at the time, are too numerous to detail their individual contributions. Instead, I will note where their contributions were made, and grant that they were all first-rate.

Layout

MaryBeth DeAnna, Suzanne Lambert, and Robert Gross

Background

MaryBeth DeAnna, Edith McClintock, and Teresa Herrero

Appendix A: Visual Preference Survey - Bus Stop Features

Sara Forelle, Clare Vickery, and Carolyn Tenn

Appendix B: Mode Share Analysis - Land Use Influences

Todd Messenger

Appendix C: Ridership Analysis - Urban Design Factors

Clare Vickery, Jeanne Mills, and Edith McClintock

The visual preference survey of Appendix A was conducted with the help of the Sarasota County Transportation Authority. We supplied the slides, survey forms, and small inducements to participate. Jay Goodwill and Bruce McQuade of the Authority did the rest, including recruiting the transit users, transit professionals, and members of the general public who participated.

The bus ridership analysis of Appendix C was performed with data and other assistance from Vilma Ceballos, Metropolitan Dade County Office of Computer Services and Information Systems; Frank Baron and Michael Moore, Dade County Metropolitan Planning Organization; and Steve Alperstein, Metro-Dade Transit Agency.

My thanks to all these people. Also, a special thanks to my project manager at the Florida Department of Transportation, Tara Bartee, for her patience and support.

Reid Ewing

Ft. Lauderdale

March 1996



I. Introduction

Urban design differs from planning in scale, orientation, and treatment of space. The scale of design is primarily that of the street, park, or transit stop, as opposed to the larger region, community, or activity center. The orientation of design is aesthetic, broadly defined. Design lies somewhere between art, whose object is beauty, and planning, whose object is functionality. The treatment of space in design is three-dimensional, with vertical elements as important as horizontal in designing street space, park space, and other urban spaces. Planning, on the other hand, is a singularly two-dimensional activity (as illustrated by everything being represented in plan view).¹

Another manual prepared for the State of Florida, *Best Development Practices - Doing the Right Thing and Making Money at the Same Time*, approaches development and redevelopment from a planning perspective. Scant attention is paid to aesthetics, small-scale elements, and the vertical dimension of development. This manual takes the opposite tack, giving more attention to design than planning issues. The two are meant to be read in tandem.

There is Hope!

There has been much comment about the absence of good urban design in Florida's suburbs and suburb-like cities and towns. No doubt the absence of good design contributes to the state's auto-dependence. Studies report much higher walk, bicycle, and transit mode shares in places with pedestrian- and transit-oriented designs.²

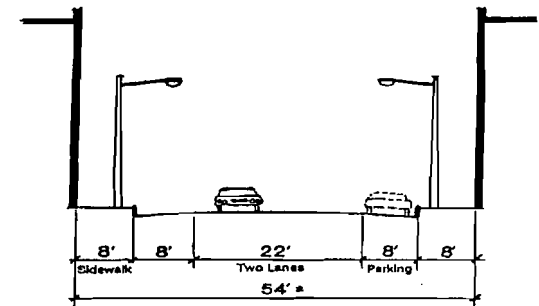
Many older cities and towns in Florida are trying desperately to reestablish the pedestrian orientation of an earlier time. In another volume, this author highlights the efforts of one Florida city, Orlando, to pedestrianize and transitize its urban core.³ Orlando is one of the few Florida cities to prepare an urban design element as part of its comprehensive plan. The element designates downtown Orlando and surrounding neighborhoods as the "traditional city." Special urban design standards have been adopted to bring buildings up to the street, minimize curb cuts and midblock gaps, ban blank walls and pole-mounted signs, and make pedestrian connections to the public sidewalk. These urban design standards are complemented by:

- zoning regulations that encourage medium-to-high densities and mixed land uses,

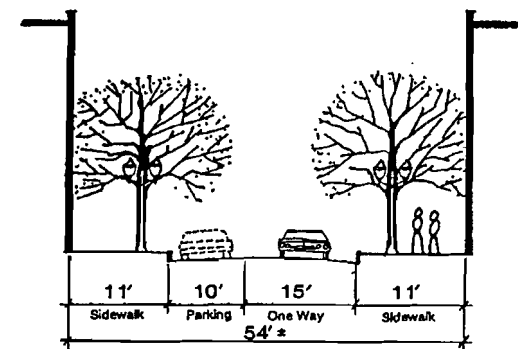
- tax-increment-financed streetscape improvements, and
- a transit development program that includes off-street parking limitations, exclusive bus lanes, and satellite parking garages.

Programmed Streetscape Improvements (Orlando)

EXISTING



PROPOSED



Source: City of Orlando, Fla., *Downtown Orlando Streetscape Design Guidelines*, 1988.

Resulting Streetscape (Orlando)



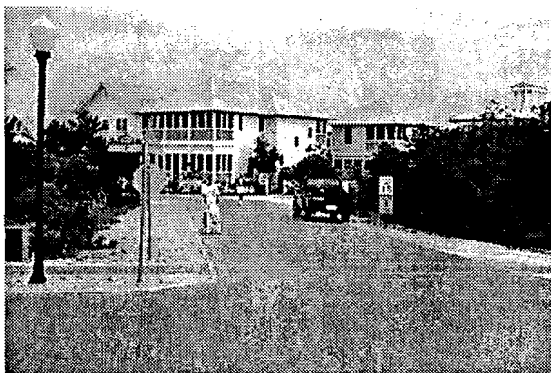
Orlando's experience shows that even in Florida, the epitomy of auto-dependence, transit can make inroads. Transit ridership in Orlando has almost doubled since 1990.

Suburban design until recently has been more of an oxymoron than an established field. Times are changing. One group of designers advocates traditional small town designs for the suburbs; Florida is home to leading "neo-traditionalists" and the most widely recognized example of neo-traditional development, the resort community of Seaside.⁴ Another allied group advocates pockets of urban and urbane development amidst the low densities of suburbia. The designer who invented the "pedestrian pocket" points to a Florida development, Mizner Park in Boca Raton, as a built example of his brainchild.⁵ A third group simply strives to make individual elements—the suburban arterial, the subdivision, the shopping center—more

attractive and pedestrian-friendly.⁶ Florida examples (illustrated with photos) are presented throughout this manual.

So there is hope!

First Neo-Traditional Community (Seaside)



"Pedestrian Pocket" (Mizner Park, Boca Raton)



Sources

The checklist in Chapter II is the heart and soul of this manual. It draws primarily on three sources—the classic urban design literature, the best transit-oriented design manuals, and our own transit-related studies undertaken to give this manual an empirical base.

Urban Design Literature

To avoid endless citations later on, classic readings in urban design and site planning are given due credit here. Readings that came early and shaped the thinking of those who followed include:

Camillo Sitte, *City Planning According to Artistic Principles*, Verlag von Carl Graeser, Vienna, 1889 (complete translation in G.R. Collins and C.C. Collins, *Camillo Sitte: The Birth of Modern City Planning*, Rizzoli International Publications, New York, 1986, pp. 129-409).

Raymond Unwin, *Town Planning in Practice*, T. Fisher Unwin, Ltd., London, 1909 (reissued by Princeton Architectural Press, New York, 1994).

Jane Jacobs, *The Death and Life of Great American Cities*, Random House, New York, 1961.

Kevin Lynch, *Site Planning*, MIT Press, Cambridge, MA, 1962 (latest edition co-authored with Gary Hack and published by MIT Press in 1984).

Christopher Tunnard and Boris Pushkarev, *Man-Made America - Chaos or Control?* Yale University Press, New Haven, CT, 1963.

Christopher Alexander, Sara Ishikawa, and Murray Silverstein, *A Pattern Language - Towns · Buildings · Construction*, Oxford University Press, New York, 1977.

Seminal works in specialty areas of design include:

John Fruin, *Pedestrian Planning and Design*, Metropolitan Association of Urban Designers and Environmental Planners, Inc., New York, 1971 (revised and published in 1987 by Elevator World, Mobile, AL).

William H. Whyte, *The Social Life of Small Urban Spaces*, The Conservation Foundation, Washington, D.C., 1980 (much of the same material appears in Whyte's later book, *City - Rediscovering the Center*, Doubleday, New York, 1988, pp. 103-173).

Roger Trancik, *Finding Lost Space - Theories of Urban Design*, Van Nostrand Reinhold, New York, 1986.

Henry Arnold, *Trees in Urban Design*, Van Nostrand Reinhold, New York, 1993.

Allan Jacobs, *Great Streets*, MIT Press, Cambridge, MA, 1993.

There are also seminal works on less critical subjects such as signage, public art, street furniture, and parking lot design.⁷

Finally, a few books are so cleverly written and neatly packaged as to stand out from other broad-brush works. For local officials, planning students, or citizen activists, these may be the best place to start learning about urban design.

Richard Hedman, *Fundamentals of Urban Design*, American Planning Association, Chicago, IL, 1984.

Richard Untermaier, *Accommodating the Pedestrian - Adapting Towns and Neighborhoods for Walking and Bicycling*, Van Nostrand Reinhold, New York, 1984.

Peter Calthorpe, *The Next American Metropolis - Ecology, Community, and the American Dream*, Princeton Architectural Press, New York, 1993.

David Sucher, *City Comforts - How to Build an Urban Village*, City Comforts Press, Seattle, WA, 1995.

Transit-Oriented Design Manuals

In just over a decade, transit-oriented design (TOD) has become prominent as a topic of study and area of application. About 40 manuals are now available in North America with many more to come.⁸ Some are land planning/urban design manuals with a transit orientation. Others are transit facility design manuals with implications for urban design. The former emphasize the needs of transit users accessing the system, the latter the needs of the transit operator running the system.

These manuals overlap somewhat with the classic urban design literature, but transit-oriented design is both more and less than urban design—more in the sense that additional topics are covered, less in the sense that design issues tend to be dealt with superficially.

Of the 40, the most useful to us were a 1989 manual that identified key features now accepted as transit-oriented; a 1992 manual with a particularly complete approach to the subject; a 1993 manual with outstanding graphics; and a 1994 manual with a new slant on "customer amenities":

Snohomish County Transportation Authority, *A Guide to Land Use and Public Transportation*, Lynnwood, WA, 1989 (updated and fully illustrated in *Volume II*, 1993).

Ontario Ministry of Transportation, *Transit-Supportive Land Use Planning Guidelines*, Toronto, 1992.

Denver Regional Council of Governments, *Suburban Mobility Design Manual*, Denver, CO, 1993.

Herbert Halback, Inc., *Customer Amenities Manual*, Central Florida Regional Transportation Authority, Orlando, 1994.

TOD manuals prepared by Calthorpe Associates for Sacramento County, San Diego, Portland, and Santa Clara County are not listed here only because they are recapped in Peter Calthorpe's book, referenced above.

Our Own Empirical Studies

Appendix A presents the first-ever (to our knowledge) visual preference survey related to transit facility design. Given slides, photos, or graphic images, it is possible to determine statistically what features must be important to people from their ratings of, or choices between, scenes. Such a survey and analysis were accomplished using slides of bus stops as the medium and transit users and nonusers in Sarasota as the subjects.

Appendices B and C present analyses of transit usage in Dade County, home of Miami. One analysis explains transit mode shares within small areas (traffic analysis zones), the

other transit ridership at sampled bus stops. The analyses together tell us which land use and urban design characteristics significantly affect transit ridership, either alone or in combination with one another.

II. Checklist of Pedestrian- and Transit-Friendly Features

This chapter provides a checklist of pedestrian- and transit-friendly design features that would, ideally, be built into all transit-served areas. Features are illustrated with photos from Florida and elsewhere, and with graphics reproduced from award-winning design manuals.

Features fall into three classes: those deemed essential; those deemed highly desirable; and those deemed nice but somewhat incidental. Even the third class will encourage street life, walking, and transit use, but for transit operators, local governments, and developers, the priorities are as indicated.

It must be acknowledged, up front, that sorting pedestrian- and transit-friendly features into three classes involves a leap of faith. But sort we must. Choices must be made in the alignment of transit routes, in the amenities offered at transit stops, and in the development practices that are required versus simply encouraged.

We are led, by our own data and analysis, to conclude that some features deemed essential for general walkability may not be all that important to the subset of pedestrians accessing transit systems. Transit users may be less sensitive to the pedestrian environment because they are traveling for utilitarian purposes such as work and/or because

they are spending only a fraction of their door-to-door travel time on foot. Whatever the reason, pedestrian-friendly design is not exactly the same as transit-oriented design.

Essentials

Medium-to-High Densities

Densities in the U.S. have taken a nose dive over the past 40 years. Before mechanized transportation, gross densities were in the range of 40 to 80 people per acre; such densities compressed enough activities into a small area to allow people to walk to almost everything. Today, in developing areas, gross densities are 1/10 the historical norm. Such low

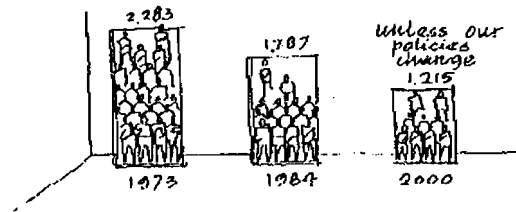
densities are practical only because the automobile allows us to overcome great distances.

The mere mention of density sends shivers down the spines of many residents and elected officials. In this regard, density has gotten a bum rap. People confuse density with crowding, density being the number of dwelling units per unit area and crowding the number of persons per room in dwelling units.⁹ Crowded conditions have no redeeming value, while high density living can be very desirable, as indicated by the high housing prices and rents commanded by the Georgetown (and South Miami Beaches) of this world.

People confuse high density with high rise. High densities can be achieved with small-scale buildings by raising lot coverages to 50, 60, or even 70%. Conversely, high-rise buildings afford only moderate densities if surrounded by acres of parking and lawn. Pedestrians are comfortable with small-scale buildings and high lot coverages. They are uncomfortable with high-rise towers and low lot coverages. "...much of the criticism of high-rise living and its socially alienating effects is not due to its high density but to its low density at ground level," where nearly all human interaction must occur.¹⁰

Urban Density Trends in Florida

Florida's Urban Density Trend
(persons/square mile)



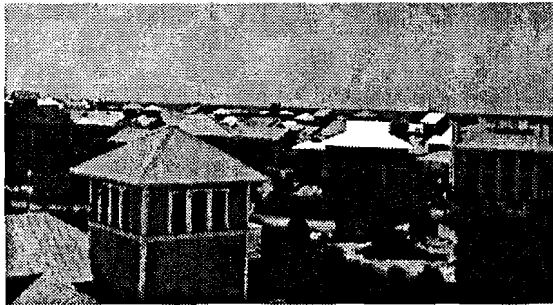
Source: Adapted from Governor's Task Force on Urban Growth Patterns, *Final Report*, Florida Department of Community Affairs, Tallahassee, 1989, p. 8.

*About 10 Units Per Net Acre
without Crowding*

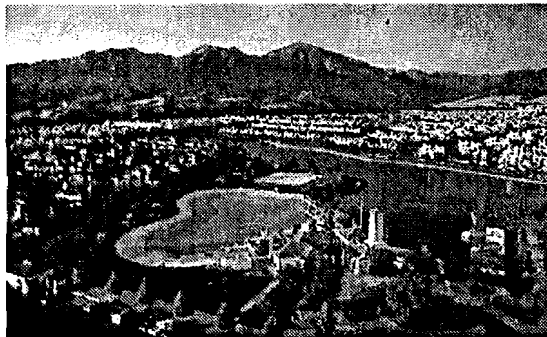
Miami Lakes



Seaside



Rancho Santa Margarita, CA



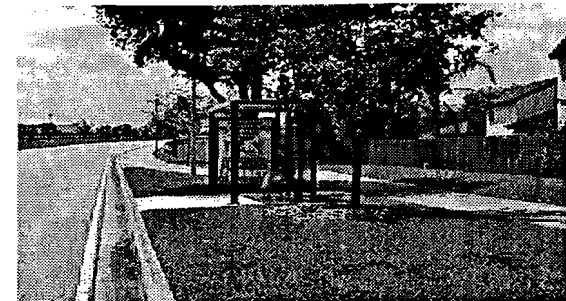
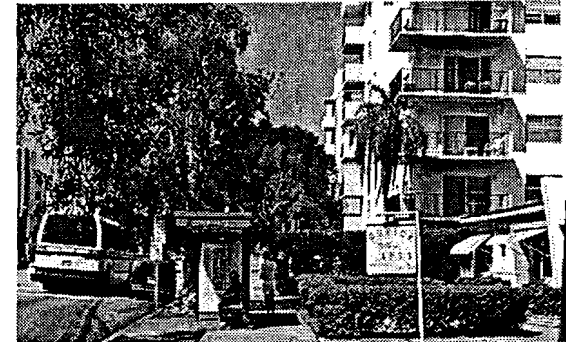
Finally, people confuse perceived density with measured density. We know, for example, that densities are perceived to be lower where there is open space nearby, where blocks are short, and where buildings are of moderate height.¹¹ These are all pedestrian-friendly features and, as such, are the subjects of later guidelines. See “Short-to-Medium Length Blocks,” “Nearby Parks and Other Public Spaces,” and “Small-Scale Buildings (or Articulated Larger Ones).”

The weight of available evidence points to the importance of density in promoting walking and transit use.¹² Higher densities mean more residents or employees within walking distance of transit stops and stations. They mean more street life and the added interest and security that goes with having more people around. They mean lower auto ownership rates, higher parking charges, more congestion for motorists, and thus a greater propensity to walk or use transit.

In Miami, it appears that an overall density of 23 residents or employees per acre is required to support basic bus service (see Appendix B). This is an areawide average value. Required density will vary from subarea to subarea, depending on household auto ownership rates, employee parking charges, local jobs-housing balance, and other factors. Appendix B shows how required densities can be calculated for other urbanized areas, given readily available U.S. Census data and desired levels of transit productivity.

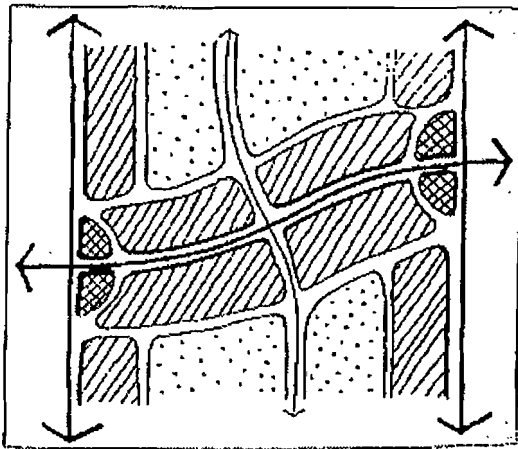
The overall density figure for Miami translates into 8.4 dwelling units per acre, slightly higher than the long-accepted standard of 7 units per acre. For premium bus service, the required residential density rises to more than 11 units per acre.

*Dense Development Around
Transit Stops in Miami*



Ideally, the very highest densities will be closest to transit stops; a density gradient will maximize transit ridership. While densities may decline with distance from stops, they will average at least 8 to 11 units per acre (in this example) within the quarter mile service areas around stops.

Transit Ridership Maximized by a Density Gradient



Source: Ontario Ministry of Transportation, *Transit-Supportive Land Use Planning Guidelines*, Toronto, 1992, p. 18.

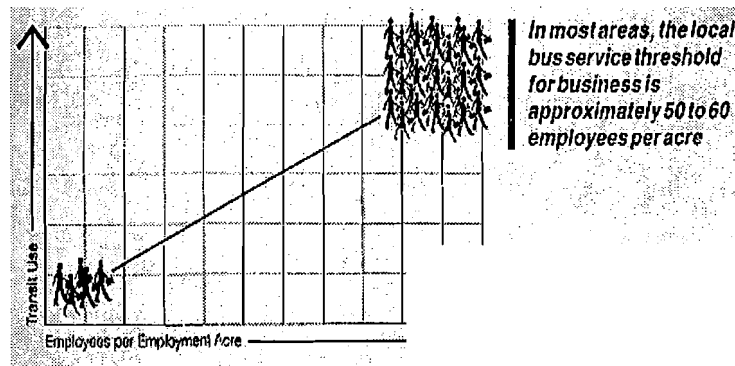
Note that indicated densities are specific to one urbanized area and assume a low level of transit productivity. They represent the point at which auto dependence just begins to give way to multimodalism. For active street life and viable neighborhood businesses, higher densities are required (see table). Higher densities are also required for reasonable transit productivity (see figures).

Minimum Net Densities for Urban "Livability"

J. Jacobs	100 units/acre
Lynch	12-20 units/acre
A. Jacobs and Appleyard	15 units/acre
Calthorpe	10-15 units/acre

Sources: J. Jacobs, *The Death and Life of Great American Cities*, Random House, New York, 1961, pp. 208-212; K. Lynch, *Site Planning*, MIT Press, Cambridge, MA, 1962, pp. 146-147; A. Jacobs and D. Appleyard, "Toward an Urban Design Manifesto," *Journal of the American Planning Association*, Vol. 53, 1987, pp. 112-120; and P. Calthorpe, *The Next American Metropolis - Ecology, Community, and the American Dream*, Princeton Architectural Press, New York, 1993, p. 83.

Transit Productivity Thresholds (According to One Source)



Source: Denver Regional Council of Governments, *Suburban Mobility Design Manual*, Denver, CO, 1993, pp. 11-12.

Mix of Land Uses

With the rise of the automobile, urban activities have become increasingly compartmentalized. Places where we work, shop, learn, and play are remote from one another, and none is within walking distance of the average American's home. "Clean zoning" has contributed to the problem by designating large areas for single-family residential uses only.

"The inclusion of varied uses within an otherwise residential environment appears to be a necessary precondition for pedestrian street activity."¹³ This is so for several reasons. A blend of nonresidential and residential uses places trip attractions within walking distance of people's homes; people are much more likely to walk when they have some place specific and nearby to go, a "strong goal" as *Christopher Alexander* put it.¹⁴

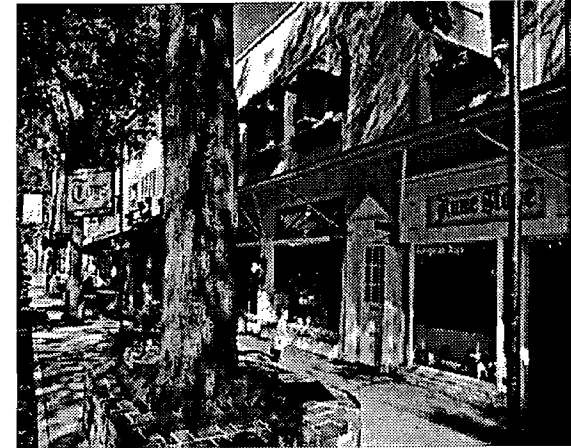
Other pedestrian-friendly qualities ascribed to mixed-use development include: architectural variety and visual interest; street security due to continual "eyes on the street"; and a greater sense of community when residents have places outside home and work to casually interact.¹⁵ These positive qualities are not guaranteed but depend on good design.

Mixed Land Uses in Old and New Towns (including Apartments Above Shops)

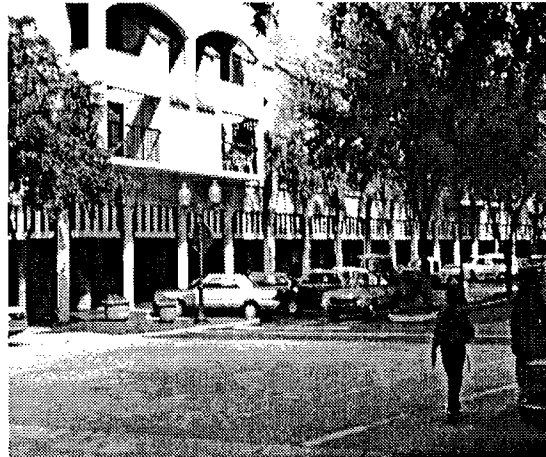
DeFuniak Springs



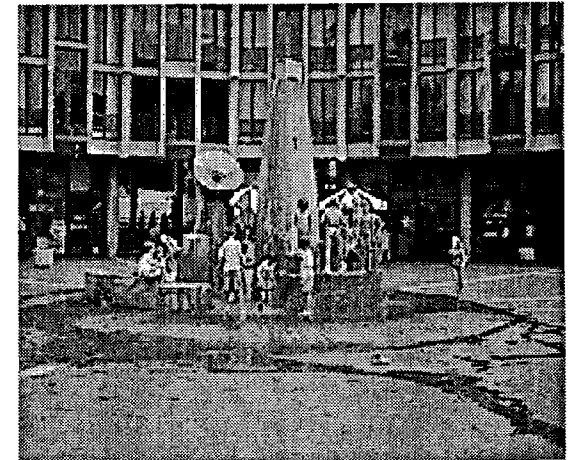
Winter Park



Miami Lakes



Reston, VA



Three Views of the "Ideal" Land Use Mix

Alexander et al.	Calthorpe (Urban Transit-Oriented Developments)	Traditional Towns (Average of Four)
Housing - 26%	Housing - 20-60%	Housing - 41%
Shops and Restaurants - 7%	Shops, Offices, etc. - 30-70%	Commercial - 10%
Community Functions - 15%	Public - 5-15%	Civic - 12%
Hotels - 5%		Parks/Open Space - 15%
Offices - 16%		Rights-of-way - 22%
Manufacturing - 12%		
Parking - 19%		

Sources: C. Alexander et al., *A New Theory of Urban Design*, Oxford University Press, New York, 1987, p. 34; P. Calthorpe, *The Next American Metropolis - Ecology, Community, and the American Dream*, Princeton Architectural Press, New York, 1993, p. 63; and R. Ewing, *Best Development Practices - Doing the Right Thing and Making Money at the Same Time*, American Planning Association, Chicago, IL, 1996, in press.

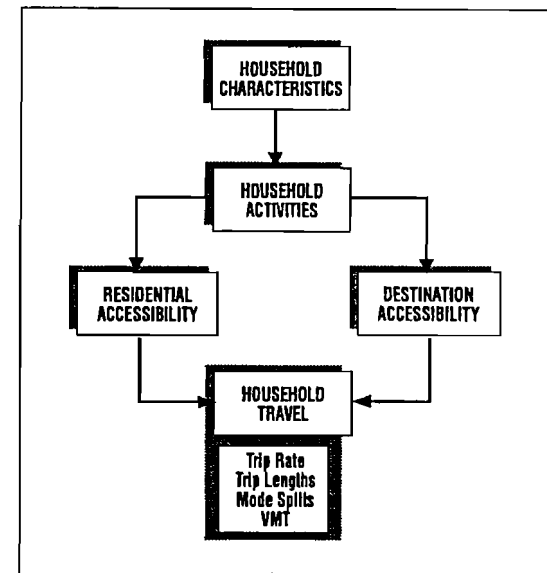
Insofar as a mix of uses makes for a nicer walking environment, or allows transit users to run errands on the way to and from stops (as auto users run errands on the way to and from their primary destinations), transit ridership should grow as land uses become more varied and integrated. Not all empirical studies have found this to be the case.¹⁶ Our own research suggests a weak relationship between jobs-housing balance in workers' home zones and the share of workers using transit; the degree of land use mixing seems to make no difference (Appendix B). Jobs-housing balance in the area

around bus stops proves unrelated to ridership at particular stops, as does the degree of land use mixing in the area around stops (Appendix C).

Basically, if medium-to-high densities exist within transit-served areas, it seems to matter only a little whether potential riders are residents, employees, customers, or a mix. Were transit ridership our sole concern in this manual, this feature—having a mix of land uses—would slip from the first to the second tier of pedestrian- and transit-friendly features.

Here are some guidelines for planning mixed-use areas. Two kinds of accessibility are important. Proximity of activities to one's place of residence—so-called residential accessibility—affects the length, mode, and arguably, even the frequency of home-based trips.¹⁷ A second type of accessibility gets less attention but is also important. Destination accessibility—proximity of activities to one another—affects travelers' ability to link trips efficiently into tours or, better still, complete more than one activity at a single stop.¹⁸ Travelers may use the automobile for access, but once at a destination with a rich mix of uses, they can conduct their business on foot.

Household Travel Patterns as a Function of Accessibility

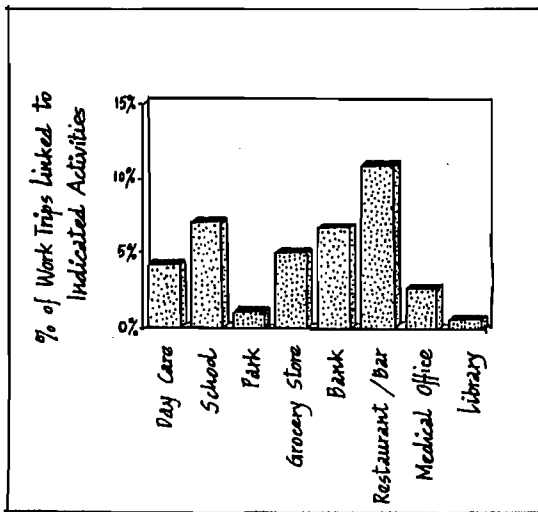


Source: R. Ewing, "Beyond Density, Mode Choice, and Single-Purpose Trips," *Transportation Quarterly*, Vol. 49, 1995, pp. 15-24.

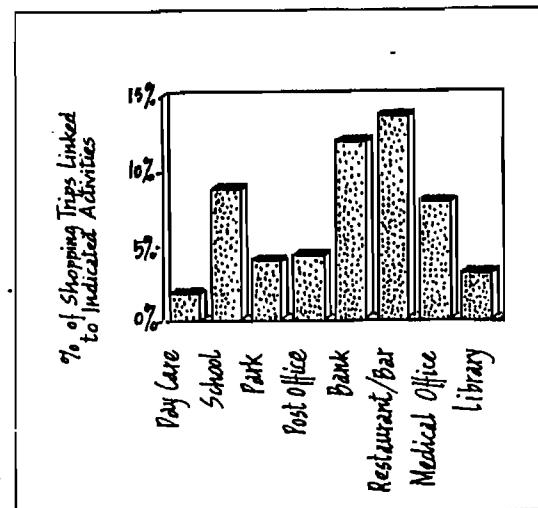
Walking distances vary with the age of travelers, purpose of trips, and quality of the walking environment. The curves below suggest that activities be placed no more than 1/4 mile from housing if walking is to be a serious mode of travel.

Certain activities tend to be combined with work and shopping in multi-purpose trips and tours. The figures to the side, based on a household travel survey in Palm Beach County, show which land uses are so linked and hence belong within employment and shopping centers, and around transit stops and stations.

Activities Linked to Work and Shopping Trips

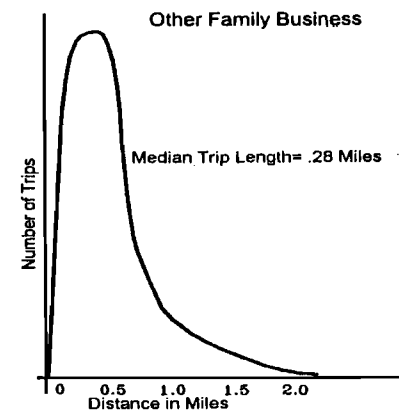
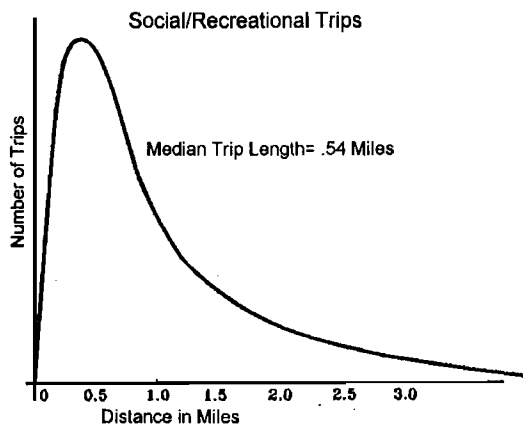
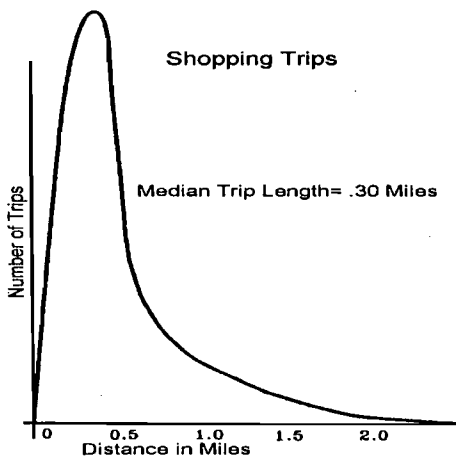


Source: Household Travel Survey, Palm Beach County, 5/91-7/91.



Source: Household Travel Survey, Palm Beach County, 5/91-7/91.

Walking Distances for Different Trip Purposes



Source: Tabulations from the 1990 Nationwide Personal Transportation Survey (NPTS). Walking distances were estimated from reported travel times, assuming everyone walked at the NPTS average speed of 3.16 mph. Curves were smoothed to account for people's tendency to round off travel times.

Short-to-Medium Length Blocks

There has been a trend toward longer and longer blocks, and correspondingly fewer and fewer intersections within a given area. This is true not only in the suburbs, where superblocks are the norm, but in central cities where blocks plus interior rights-of-ways have been consolidated to create larger building sites. "The practice (of block consolidation) contributes to a city scaled to cars and is a grave error," assuming pedestrian-friendliness is a goal.¹⁹

By mapping different cities at a common scale, *Allan Jacobs* determined that Venice, Italy, has

about 1,500 intersections in a typical square mile, while the City of Irvine outside Los Angeles, California, has 15 intersections per square mile.²⁰ Downtown Los Angeles has about one-tenth as many intersections as Venice, and 10 times as many as Irvine. People familiar with these three cities would doubtless rank their walkability in same order. Jacobs also found that downtown Boston, as an example, had lost more than one-third of its intersections through block consolidations.

Reasons why walkability depends on block size are numerous. Most obviously, more intersections mean more places where cars must stop and pedestrians can cross. Also, short blocks and frequent

cross streets create the potential for more direct routing; this is important to pedestrians, much more so than to high-speed motorists. Finally, a dense network of streets disperses traffic, so that each street carries less traffic and can be scaled accordingly; this makes streets more pleasant to walk along and easier to cross.

There may be psychological factors at work as well. It has been suggested that more intersections give pedestrians more sense of freedom and control as they need not always take the same path to a given destination; that more intersections make a walk seem more eventful, since it is punctuated by frequent crossing of streets; that more

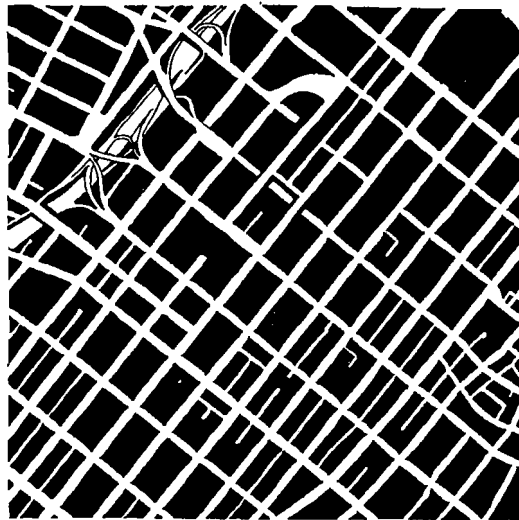
Street Maps at the Same Scale

Venice, Italy



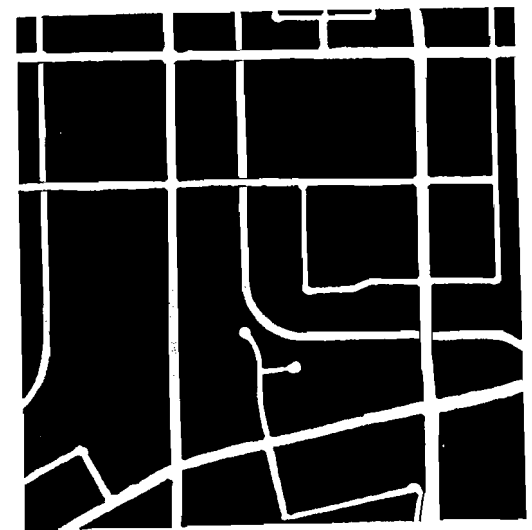
Source: A.B. Jacobs, *Great Streets*, MIT Press, Cambridge, Mass., 1993, p. 249.

Los Angeles (Downtown)



Source: A.B. Jacobs, *Great Streets*, MIT Press, Cambridge, Mass., 1993, p. 225.

Irvine, CA



Source: A.B. Jacobs, *Great Streets*, MIT Press, Cambridge, Mass., 1993, p. 221.

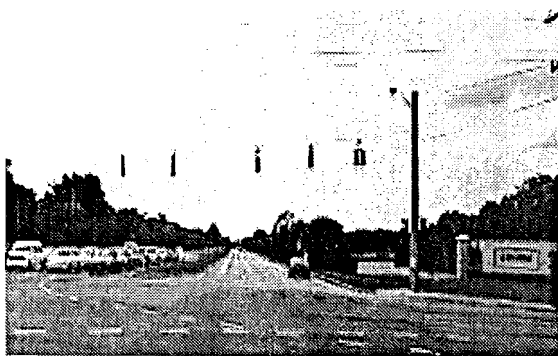
intersections may shorten the sense of elapsed time on walk trips, since progress is judged to some extent against the milestone of reaching the next intersection.²¹

This feature—short-to-medium length blocks—goes hand-in-hand with the previous one—a mix of land uses. Short blocks create lots of corners that are ideal for small-scale commerce. Residents of adjacent streets can pool their support for neighborhood businesses as their paths come together at intersections.²²

*Short Block
(Tampa)*



*Long Block
(West Boca Raton)*

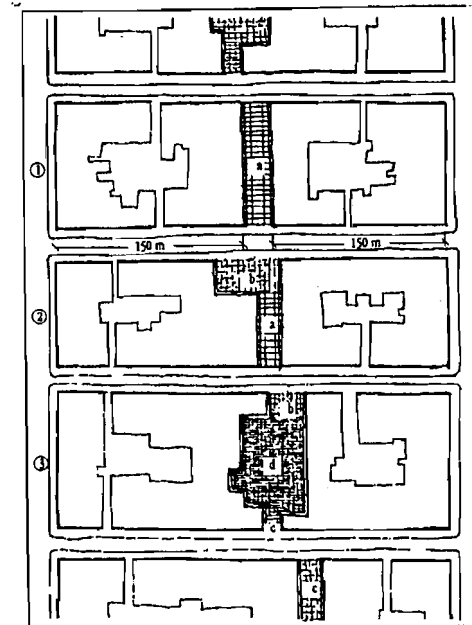


For a high degree of walkability, block lengths of 300 feet, more or less, are desirable.²³ Blocks of 400 to 500 feet still work well. This is typical of Florida's older urban areas. However, as blocks grow to 600 to 800 feet, or even worse, to super-block dimensions, adjacent blocks become isolated from each other.

If blocks are scaled to the automobile (more than 600 to 800 feet on a side), midblock crosswalks and pass-throughs are recommended.²⁴ Mind you, these devices are poor substitutes for the real thing: frequent intersections offering directional choices and frequent streets with active uses on both sides. But they are better than nothing.

Long blocks can also be broken up with alleyways (see *Best Development Practices* for a discussion of alleys, their pluses and minuses). Again, though, alleys are no substitute for frequent cross streets lined with active users.

Pass-Throughs on Blocks Longer than 150 Meters (492 Ft)



Pedestrian route as a network: 1) single open space type, 2) mixed open space type, 3) mixed open space type. Open space type: a) gallery, b) plaza, c) walkway, d) courtyard

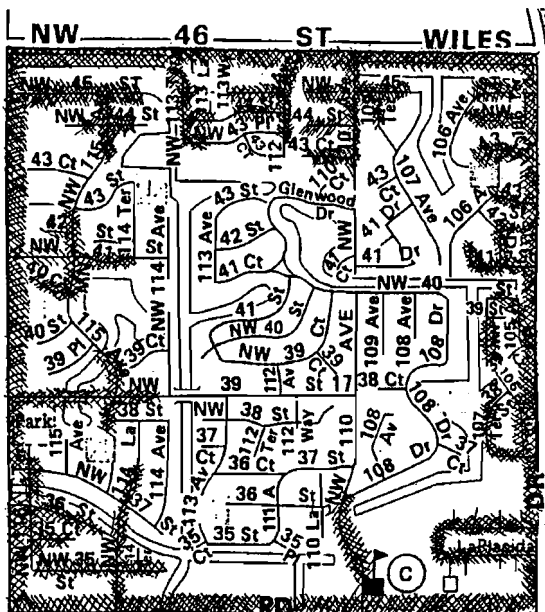
Source: City of Toronto, *Urban Design Guidebook - Draft for Discussion*, Ontario, 1995, p. 31.

Typical Block Dimensions in Older Urban Areas

	Residential	Commercial
Bradenton	400' x 1,200'	400' x 400'
Coral Gables		200' x 800'
Lake Worth		350' x 500'
Winter Park	300' x 1,200'	300' x 400'

Short blocks may be more important for general walkability than for transit ridership. In Appendix C, the number of intersections within the immediate area around bus stops does not emerge as a significant determinant of bus stop ridership in Miami. However, it does correlate highly with other pedestrian-friendly features and is the variable upon which a pedestrian-friendliness factor (extracted through factor analysis) loads most heavily. This takes us back to a previous point—if a transit-served area has enough potential riders, the precise layout of the area may matter only a little.

Superblock Mostly More than 1/4 Mile from a Through-Street (Coral Springs)



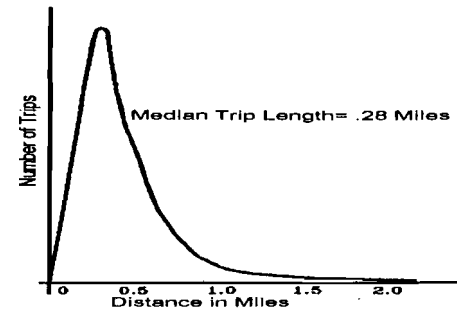
Transit Routes Every Half-Mile

As city blocks have been replaced by superblocks, the spacing of through-streets has increased. Within these large blocks, straight, continuous streets have given way to curving, discontinuous streets. The combination of curvilinear local streets and widely spaced through-streets has left few residents within walking distance of transit lines (see preceding illustration).

The old transit industry standard—that transit users will walk a quarter mile, or 5 minutes at 3 mph, to a bus stop—is better than we might have guessed. Converting reported walk times from the 1990 Nationwide Personal Transportation Survey (NPTS) into distances, and plotting and smoothing the resulting frequency curve, the median walking distance to and from transit stops is almost exactly a quarter mile.²⁵ Of course, young people may be willing to walk a little farther than older people, and users of premium transit (rail rapid transit, for example) may walk a little farther than regular bus users. But a quarter mile walking distance is a good rule-of-thumb for transit planning purposes.

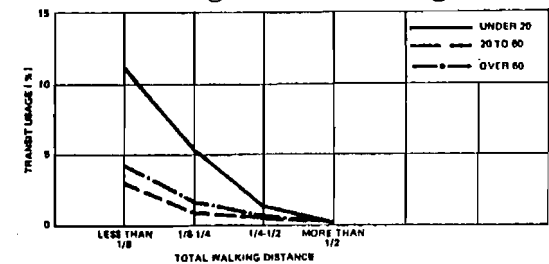
If a quarter mile is the farthest most people will walk, it follows that transit routes may be no farther than a half mile apart to blanket a service area. This assumes that transit stops are closely spaced along routes, as they usually are in the United States, and that local streets lead directly to stops, as they usually do in urban settings. If stops are infrequent or local streets are curvilinear, parallel routes must be even closer together.

Walking Distances to/from Transit Routes



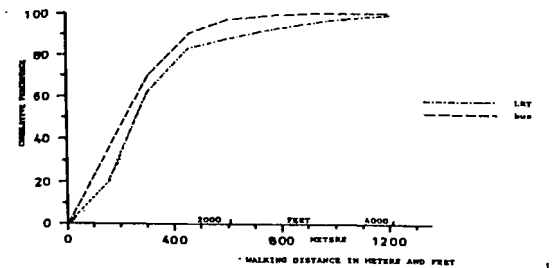
Source: Tabulation from the 1990 Nationwide Personal Transportation Survey (NPTS).

Transit Usage vs. Walking Distance and Age



Source: G.K. Neilson and W.K. Fowler, "Relation Between Transit Ridership and Walking Distances in a Low-Density Florida Retirement Area," *Highway Research Record* 403, 1972, pp. 26-34.

Cumulative Walking Distances to Bus and Light Rail Transit

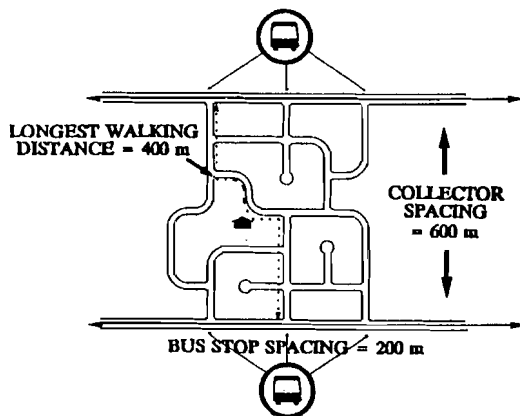


Source: P.N. Seneviratne, "Acceptable Walking Distances in Central Areas," *Journal of Transportation Engineering*, Vol. 3, 1985, pp. 365-376.

This simple logic underlies the call in many transit-oriented development (TOD) manuals for transit routes every half mile, and collectors or arterials spaced accordingly.²⁶ Collectors and arterials are favored over local streets because of their wider lanes and greater distances end-to-end.

Half-mile spacing of higher-order streets and transit routes seems a reasonable target for network density; it was embraced as a Best Transportation Practice in the companion volume, *Best Development Practices*.²⁷ For curvilinear networks, the equivalent network density is 4.0 centerline miles per square mile of land area.

*Collector/Arterial Spacing
for Transit Access
(400 meters = 0.25 miles)*



Source: W. Bowes, M. Gravel, and G. Noxon, *Guide to Transit Considerations in the Subdivision Design and Approval Process*, Transportation Association of Canada, Ottawa, Ontario, 1991, p. A-8.

**Two- or Four-Lane Streets
(with Rare Exceptions)**

As blocks have gotten longer, and grids have given way to discontinuous, curvilinear street networks, the few remaining through-streets have had to be widened to carry the same volume of traffic. In suburban America, the standard arterial cross section is now six lanes, with additional turn lanes at intersections.

Applied to street sections, the concept of human scale implies two or four travel lanes, no more. It is hard to find a six-lane road that is easy to cross, pleasant to walk along, or comfortable to wait along when using transit. Parking lanes do not count against the total of four.

One study reported higher pedestrian volumes on narrow than wide streets.²⁸ More elderly users, more bicyclists, more people out walking pets, and more pedestrians crossing back and forth all suggested greater pedestrian comfort with traffic on the narrower streets.

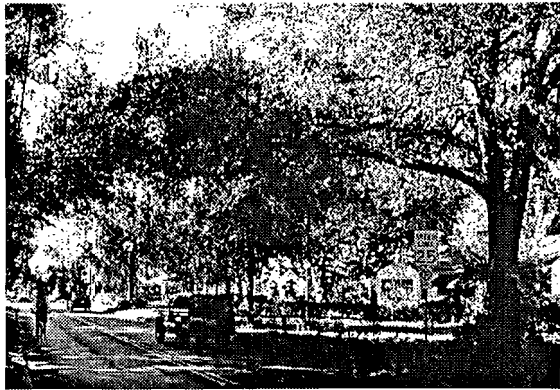
By dividing four-lane streets, they become almost as easy to cross as two-lane streets. Raised medians or islands offer pedestrians refuge half way across and allow them to focus on one direction of traffic at a time. Pedestrian accident rates are lower on streets with raised medians.²⁹ Crossing delays are substantially less.³⁰ Raised medians are particularly important in the suburbs, where long blocks encourage midblock crossings.

*Waiting for Transit on a Six-Lane Road - One Minute and the Next
(Ft. Lauderdale)*

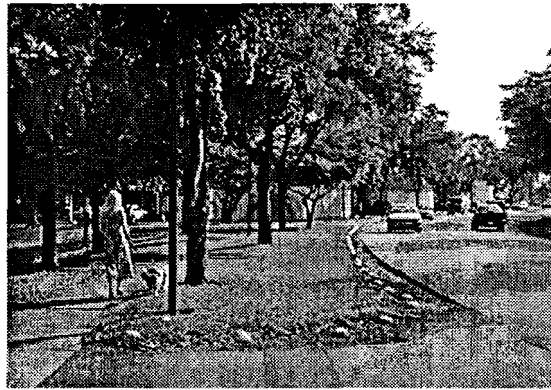


Two- and Four-Lane Streets That Are Walkable Despite Heavy Traffic

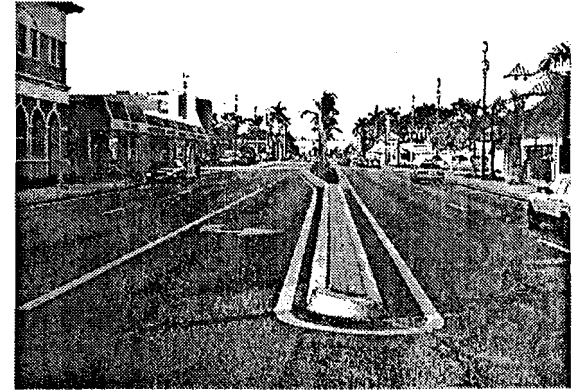
Winter Park



Miami Lakes



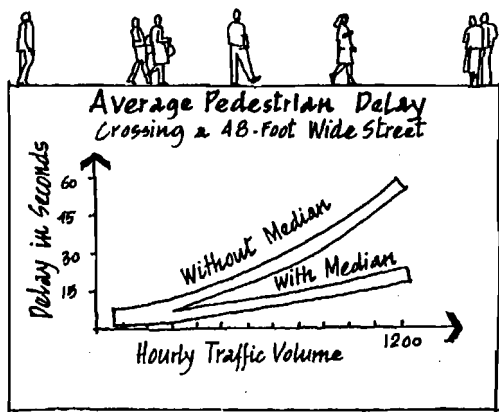
Boca Raton



As for six-lane roads, they are best avoided in pedestrian areas. Where unavoidable, they are most comfortable for pedestrians when bordering buildings provide a sense of enclosure, when sidewalks are appropriately buffered from traffic by street trees or curbside parking, and

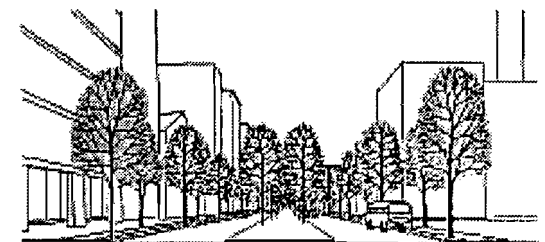
when wide, raised, planted medians break up their paved expanse. Substantial trees in the median and on either side have the power to visually divide street space in half. See "Appropriate Buffering from Traffic" and "Closely Spaced Street Trees."

Pedestrian Crossing Delay on a 4-Lane Street with and without a Median



Source: Adapted from S.A. Smith, *Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas*, National Cooperative Highway Research Program Report 294A, Transportation Research Board, Washington, D.C., 1987, p. 62.

Street Space without and with a Wide, Tree-Lined Median



Source: H. Arnold, *Trees in Urban Design*, Van Nostrand Reinhold, New York, 1993, p. 55.

This guideline goes hand-in-hand with previous guidelines calling for short blocks and frequent through-streets. Streets can be held to four lanes only if the street network is dense enough to handle the total volume of traffic. In the trade-off between more streets and wider streets, always opt for the former. Given the same number of lane-miles, a dense network of narrow-to-medium width streets has more effective capacity than a sparse network of wide streets.³¹

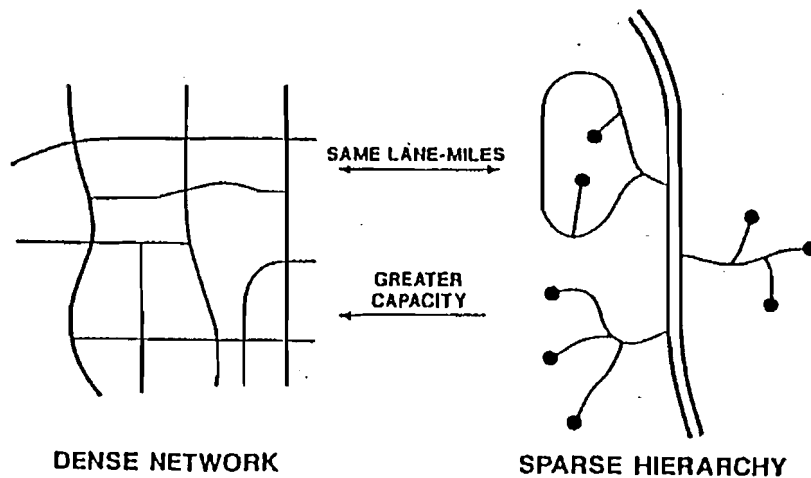
Continuous Sidewalks
Wide Enough for Couples

As American society has become increasingly auto-dependent, new streets have been built without sidewalks or with sidewalks on only

one side. In a fit of circular reasoning, traffic engineers and developers have argued against sidewalks on the ground that no one will walk anyway. The engineers and developers are right in one sense—sidewalks by themselves will not induce walking. Other pedestrian-friendly features must be present as well, which is one reason why this—the first reference to sidewalks—appears fairly late in the section.

In her famous tribute to cities and city life, *The Death and Life of Great American Cities*, Jane Jacobs devotes three chapters to the importance of sidewalks for street security, neighborly contact, and assimilation of children into adult society.³² These valuable functions are performed on top of their main function, serving as safe rights-of-way for pedestrians.

Effective Capacity of Street Networks



Source: W. Kulash, "Neotraditional Town Design — Will the Traffic Work?" Session Notes - AICP Workshop on Neotraditional Town Planning, American Institute of Certified Planners, Washington, D.C., 1991.

Lack of Sidewalk Connections

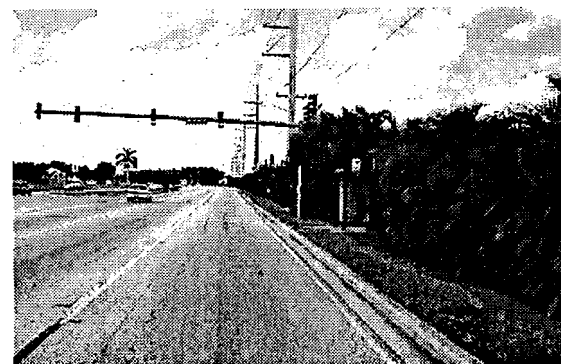
Orlando



Argyle Forest (Jacksonville)



Ft. Lauderdale



It is not enough to create isolated islands or oases for pedestrians. We must begin to provide continuous sidewalk networks for them, as we provide continuous street networks for motorists. Sidewalks are warranted on all streets except in low-density residential areas.

Just as streets are scaled to vehicular traffic volumes, so should sidewalks be scaled to pedestrian traffic volumes. Sidewalks should be wide enough to accommodate pedestrian traffic without crowding, yet not be so wide as to appear empty most of the time. A hint of crowding may actually add to the vitality and interest of the street. It is for this reason that some urban designers recommend maximum sidewalk widths, as well as minimums.

Manuals of the traffic engineering profession establish minimum sidewalk widths of 4 to 8 feet, depending on the functional class of road

and the abutting land use (see table on next page). The State of Florida has adopted a standard width of 5 feet.³³ A 5-foot sidewalk is wide enough for two people to walk comfortably

abreast, and thus represents a good dimension where pedestrian traffic is light, street furniture is limited, and buildings are set back from the sidewalk.³⁴ Where these conditions are not met, as in any respectable downtown, wider sidewalks are warranted.

*Too Wide and Too Narrow
(South Miami Beach)*



From the landmark study by John Fruin, sidewalks must provide at least 25 square feet per pedestrian to permit near-normal walking speeds.³⁵ More space is required, perhaps 40 square feet per person, to permit maneuvering around slower pedestrians and complete avoidance of oncoming and criss-crossing pedestrians. While still lively, all hint of crowding is eliminated at 100 to 150 square feet per person.³⁶ If strolling couples are to pass one another without awkward maneuvering, it takes about 10 feet of clear sidewalk width. If street lights, trash cans, newspaper boxes, and other street furniture are plentiful, an extra 2-1/2 feet of width must be allowed for clearance.³⁷ If buildings run up to the sidewalk, an additional 1 to 1-1/2 feet of width is desirable due to tendency of pedestrians to maintain this clear distance from walls.³⁸ Given such considerations, it is easy to see how some leading urban designers have arrived at sidewalk widths of 10, 15, even 20 feet as suitable for high-volume locations.

Arterials/Collectors	Both Sides
Local Streets	
Commercial Areas	Both Sides
Residential Areas	
More than 4 units/acre	Both Sides
1 to 4 units/acre	One Side
Less than 1 unit/acre	None

Source: R.L. Knoblauch et al., *Investigation of Exposure Based Pedestrian Accident Areas: Crosswalks, Sidewalks, Local Streets and Major Arterials*, Federal Highway Administration, Washington, D.C., 1988, p. 143.

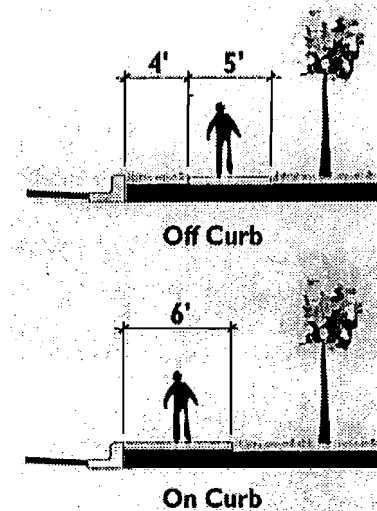
Minimum Sidewalk Widths from Traffic Engineering Manuals

	AASHTO	ASCE/NAHB/ULI*	ITE
Local Streets	4 ft (8 ft or greater may be necessary in commercial areas)	4 ft when provided (but not necessary on low-volume streets)	4-6 ft (at medium and high residential densities)
Urban Collectors/ Arterials	4 ft (residential areas) 4-8 ft (commercial areas)	4 ft with planting strip 6 ft without planting strip	4-6 ft with planting strip 6-7 ft without planting strip

* Standards apply only to residential streets.

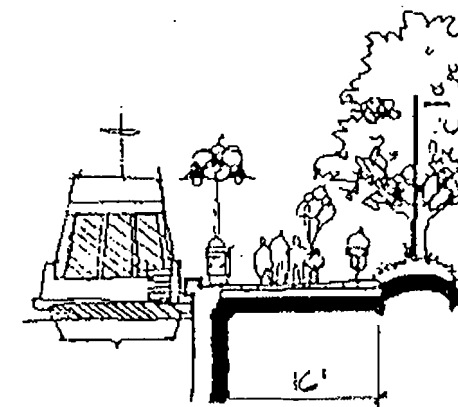
Sources: ITE Technical Council Committee 5-5, *Guidelines for Urban Major Street Design - A Recommended Practice*, Institute of Transportation Engineers, Washington, D.C., 1984, pp. 55-57; American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1990, pp. 442 and 485; Residential Streets Task Force, *Residential Streets*, American Society of Civil Engineers/National Association of Home Builders/Urban Land Institute, Washington, D.C., 1990, pp. 58-59; and ITE Technical Council Committee 5A-25A, *Guidelines for Residential Subdivision Street Design - A Recommended Practice*, Institute of Transportation Engineers, Washington, D.C., 1993, pp. 6-8 and 13.

5- or 6-Foot Sidewalk for Light Pedestrian Traffic



Source: Glattig Jackson Kercher Anglin Lopez Rinehart, Inc., *Central Florida Mobility Design Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 2-6.

16-Foot Sidewalk for Heavy Pedestrian Traffic



Source: Edward D. Stone, Jr. and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 3.5.

Recommended Sidewalk Widths at High-Volume Locations

Alexander et al.	12 ft minimum/20 ft maximum
Untermann	8-9 ft minimum/12 ft desirable
Smith et al.	12-15 ft
Whyte	15 ft minimum/30 ft maximum
Calthorpe	15-20 ft
Sucher	12 ft

Sources: C. Alexander, S. Ishikawa, and M. Silverstein, *A Pattern Language - Towns □ Buildings □ Construction*, Oxford University Press, New York, 1977, pp. 171 and 287; R.K. Untermann, *Accommodating the Pedestrian - Adapting Towns and Neighborhoods for Walking and Bicycling*, Van Nostrand Reinhold Company, New York, 1984, p. 105; S.A. Smith et al., *Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas - Research Report*, National Cooperative Highway Research Program Report 294A, Transportation Research Board, Washington, D.C., 1987, p. 52; W.H. Whyte, *City - Rediscovering the Center*, Doubleday, New York, 1988, pp. 76-78 and 93-94; P. Calthorpe, *The Next American Metropolis - Ecology, Community, and the American Dream*, Princeton Architectural Press, New York, 1993, p. 79; and D. Sucher, *City Comforts - How to Build and Urban Village*, City Comforts Press, Seattle, WA, 1995, p. 142.

Safe Crossings

As streets have gotten wider, blocks longer, and design speeds higher, street crossings have become hazardous. Even at supposedly safe signalized interactions, pedestrians crossing with the signal are exposed to danger from turning motorists. Street corners have been rounded off; motorists making right turns need hardly slow down. Right-turn-on-red has become near-universal; motorists often look to their left for oncoming traffic rather than their right for crossing pedestrians. Motorists making left turns do so under protected conditions at multi-phase signals; having exclusive turn arrows, they tend to turn without carefully scanning their environment for pedestrians.

After sidewalks, the next most important pedestrian safety feature is marked and lighted crosswalks. Most injuries and fatalities occur as

pedestrians attempt to cross streets, and most are at night.³⁹ Accident rates are significantly lower where marked crosswalks are provided and crossings are lighted.⁴⁰

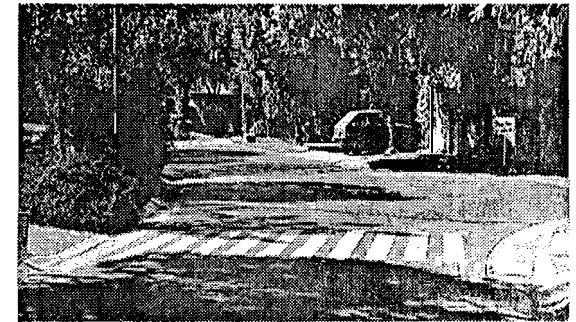
In our analysis of ridership at selected bus stops (Appendix C), the number of marked crosswalks in the immediate vicinity of stops proved a highly significant variable. This finding should not be taken too literally, as the number of marked crosswalks doubtless serves as a proxy for many aspects of pedestrian- and transit-friendly design. Nor should it be dismissed as spurious, since ease of street crossing is essential for walkability and transit access.

Richard Untermann, a leading authority on pedestrianization, recommends marked crosswalks every 100 feet on pedestrian streets.⁴¹ To maintain such close spacing, crosswalks must be provided at midblock locations. While some

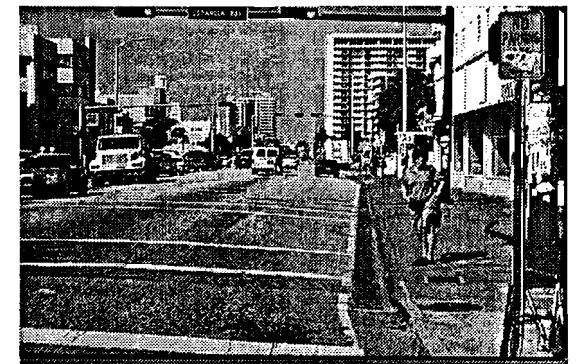
traffic engineers are less-than-enthusiastic about them, midblock crosswalks have two salutary effects: they slow down traffic in the immediate vicinity, and they discourage pedestrians from crossing between parked cars.⁴²

Closely Spaced Crosswalks

Village Homes (Davis, CA)



South Miami Beach



Dangerous Crossings

Orlando



Palo Alto, CA



Outside cities, where superblocks are the norm, many pedestrians are simply unwilling to walk all the way to an intersection.⁴³ FHWA guidelines call for midblock crosswalks whenever pedestrian traffic is heavy and blocks are more than 600 feet long.⁴⁴ Because drivers do not expect to encounter them, midblock crosswalks should be well-marked and outfitted with advance warning signs, warning flashers, and/or pedestrian-activated signals. If true pedestrian safety is the object, exclusive pedestrian signals will provide it.⁴⁵

Pedestrian crossings can be simplified, and pedestrian safety improved, by designing street corners to be sharp rather than rounded. Historically, corners had radii of 2 to 5 feet; they are now 25 to 50 feet, often more. The larger radii lengthen crossing dis-

tances for pedestrians (first figure). They allow motorists to negotiate corners without slowing down much (second figure). And they encourage dangerous "rolling stops."

Small Corner Radius in a Traditional Town (Dade City)



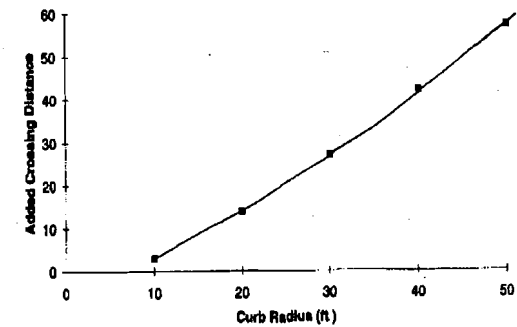
Large Corner Radius in a Contemporary Development (Hunter's Creek, Orlando)



Well-Marked Crosswalk with a Pedestrian Signal (Bal Harbour)

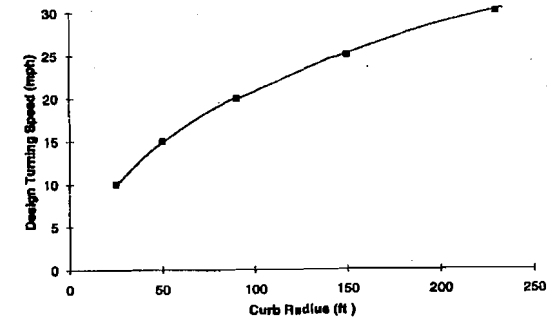


Crossing Distances vs. Corner Radii



Source: American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1990, p. 714.

Turning Speeds vs. Corner Radii



Source: Adapted from American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1990, p. 197.

Untermann recommends a corner radius of only 5 to 10 feet on streets with curbside parking; with curbside parking, vehicles turning from the travel lane have a much larger effective corner radius.⁴⁶ He also recommends a 5- to-10-foot radius on low-volume residential streets without parking lanes; the occasional service or emergency vehicle can swing wide into the opposing travel lane when traffic is light.

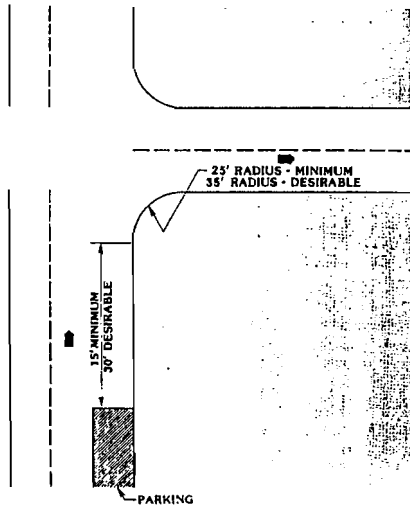
Other sources are more conservative in a traffic engineering sense, starting with corner radii of 10 to 15 feet and adjusting upward as truck/bus volumes become significant. Minimum corner radii from standard sources appear in the accompanying table. All apply to design speeds of less than 10 mph. At these speeds, road curvature is determined by the minimum turning radii of vehicles, not by their centripetal force. Corner radii can be reduced relative to the values in the accompanying table whenever vehicles are turning off of streets with curbside parking or onto streets with multilane cross sections.⁴⁷ For minimum radii at intersections with heavy bus turning movements, see the figures on the following page.

<i>Minimum Corner Radii</i>			
FDOT	AASHTO	ASCE/NAHB/ULI	British*
25 ft (where turning roadway criteria not used)	Local Streets 10-15 ft	Local-Local 15-20 ft	Low-Volume Roads 13 ft
	Arterial-Minor Cross Street 25 ft	Local-Collector 25-30 ft	Residential Streets 20 ft
Otherwise AASHTO standards	Arterial-Major Cross Street 30 ft	Collector-Collector 25-30 ft	Distributors 33 ft
	Arterial-Arterial 40 ft**		

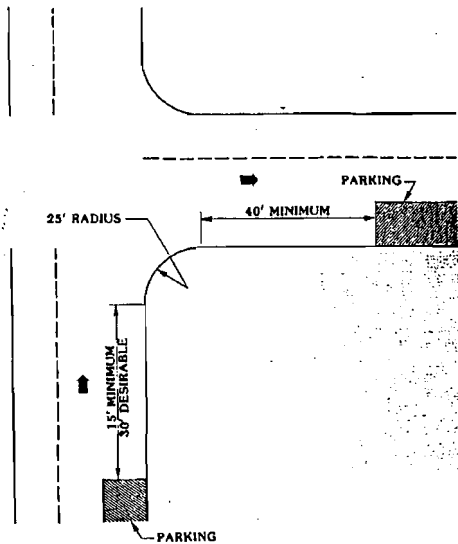
* Converted from meters and rounded off.
 ** Applies wherever buses and large truck combinations turn frequently.

Sources: American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1990, pp. 445 and 706-713; Residential Streets Task Force, *Residential Streets*, American Society of Civil Engineers/National Association of Home Builders/Urban Land Institute, Washington, D.C., 1990, pp. 58-59; J. Noble and A. Smith, *Residential Roads and Footpaths - Layout Considerations - Design Bulletin 32*, Her Majesty's Stationary Office, London, 1992, p. 49; and Florida Department of Transportation (FDOT), *Manual of Uniform Minimum Standards for Design, Construction, and Maintenance for Streets and Highways* (The Green Book), Tallahassee, 1994, pp. III-72 and III-73.

Minimum Corner Radii for Bus Turning Movements (with On-Street Parking)



Source: Maryland Department of Transportation and Mass Transit Administration, *Access by Design: Transit's Role in Land Development - A Developer's Manual*, Baltimore, MD, 1988, p. 57.



Source: Maryland Department of Transportation and Mass Transit Administration, *Access by Design: Transit's Role in Land Development - A Developer's Manual*, Baltimore, MD, 1988, p. 61.

Pedestrian crossings can be further simplified, and pedestrian safety enhanced, by flaring sidewalks at intersections and midblock crosswalks. This is the exact opposite of what is usually done at intersections; corners are usually cut back to make room for turning vehicles. Sidewalks flared in this manner form safe crosses. Safe crosses reduce crossing distances and make waiting pedestrians more visible to motorists. They also calm traffic, as discussed in "Traffic Calming Along Access Routes."

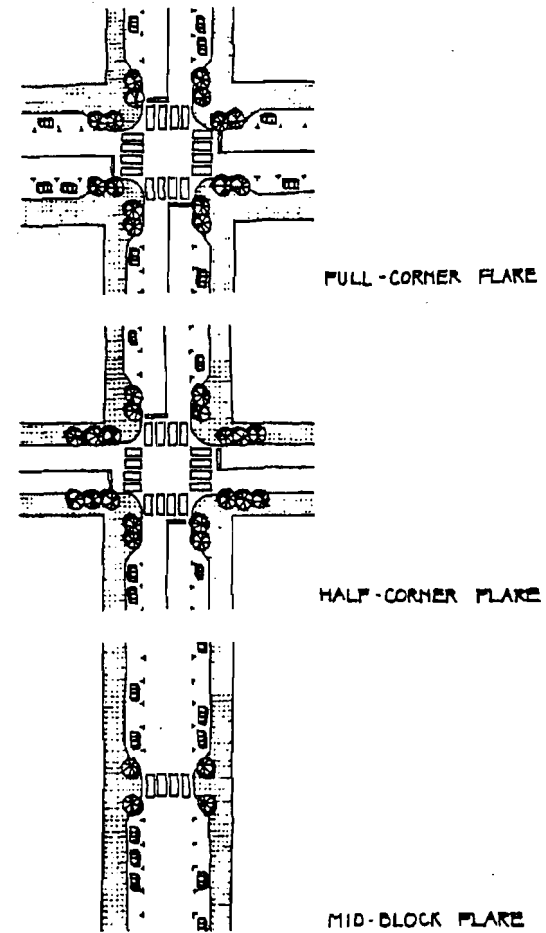
Safe crosses are nothing more than narrowings, chokers, or whatever you choose to call them, combined with crosswalks. When further combined with curbside parking, safe crosses form protected parking bays. They have become a standard part of downtown improvement projects in Florida and elsewhere. When combined with speed tables (raised to the level of sidewalks), crosswalks form what are some-

Safe Cross (San Luis Obispo, CA)



times called thresholds or plateaus, powerful traffic calming devices placed where they will do the most good for pedestrians. Thresholds/plateaus have become common in Europe and Australia.

Sidewalks Flared to Form Safe Crosses



Source: City of Toronto, *Urban Design Guidebook - Draft for Discussion*, Ontario, 1995, p. 25.

Appropriate Buffering from Traffic

There was a time, not long ago, when planners and designers thought it wise to completely separate pedestrians from automobile traffic. Pedestrian pathways were built through open spaces of planned communities. Pedestrian malls were created by closing off downtown streets.

The popular view has changed. Pedestrians and automobiles are now thought to belong in the same environment, each providing natural surveillance and human activity for the other. Sidewalks have been installed in planned communities that once relied on off-street pathways.⁴⁸ Pedestrian streets have been “demalled” to once again accept automobile and bus traffic.⁴⁹

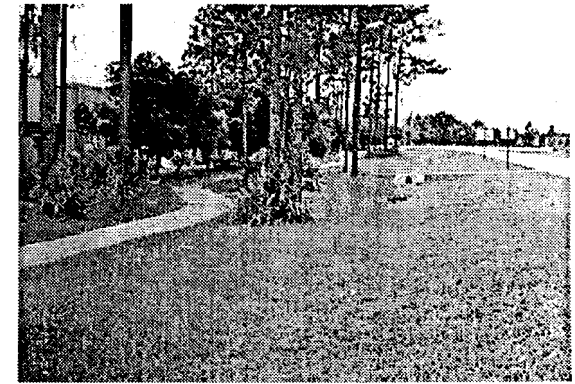
In rare instances, pedestrians and automobiles can literally share space. Where a “positive mix” of the two exists, and pedestrians dominate (as on some college campuses and at some tourist attractions), minimal separation may be required.⁵⁰ Where streets are traffic-calmed to *Woonerven* standards, as occurs mostly in Europe (see “Traffic Calming Along Access Routes”), no separation is required.

More often, pedestrians will not be comfortable unless a separation exists between themselves and automobiles. What seems appropriate to pedestrians will vary with the speed and volume of traffic. Design speeds, established for streets of different types in *Best Development Practices*, suggest thresholds beyond which greater separation and buffering are required. Design speeds are the safe speeds at which traffic naturally travels. They are distinct from posted speeds, which tend to be set lower than design speeds and are, accordingly, ignored by many motorists.

For design speeds of 20 mph or less, it is only necessary that streets have sidewalks and vertical curbs; no extra separation or buffering is required. For design speeds of 20 to 35 mph, sidewalks should either be set back behind planting strips or be wide enough themselves to afford equivalent separation from traffic; people feel the presence of passing automobiles on 5- or 6-foot sidewalks at back of curb.⁵¹ At these design speeds, a parking lane may substitute for a planting strip or extra-wide sidewalk.⁵² Beyond 35 mph, a physical barrier (or wide separation) must be provided for pedestrian comfort. The ideal barrier is a row of street trees in the planting strip between the street and sidewalk. Street furniture, guardrails, or very high curbs may substitute in special cases.⁵³

Traffic Buffers of Various Types

Argyle Forest (Jacksonville)



Miami



San Luis Obispo, CA



While not required at all design speeds, a row of street trees in the planting strip is always desirable (see "Closely Spaced Shade Trees Along Access Routes"). On urban streets with vertical curbs

and low design speeds, trees can be planted close to the curb without violating any engineering standard. Eliminate the curb while maintaining a moderate design speed, and trees may still be near the

street edge. Raise the design speed and all bets are off. The following table presents engineering standards related to curbing, planting strips, and tree/obstacle clearance.

Engineering Standards for Urban Streets

	FDOT	AASHTO	ASCE/NAHB/ULI	ITE
Curbing	vertical curbs standard on urban sections with design speeds up to 45 mph	vertical curbs (local streets and collectors) vertical curbs and shoulders in heavily developed areas (arterials)	vertical or mountable curbs at higher densities (local streets and collectors)	vertical curbs (except on local streets at low densities)
Minimum Planting/ Buffer Strip		2 ft (where strips are provided - where not provided, sidewalks should be 2 ft wider than normal)	3-5 ft desirable (applies mainly to collectors)	5-6 ft (local streets) 10 ft (residential collectors) 5-10 ft (other major streets)
Minimum Tree/ Obstacle Clearance	2.5-4.0 ft (with vertical curbs) 6-30 ft (without curbs, depending on design speed and traffic volume)	1.5 ft (with vertical curbs) rural standards apply in the absence of curbs	3 ft (local streets and collectors)	1.5 ft (with vertical curbs) 7 ft (with mountable curbs)

Sources: ITE Technical Council Committee 5-5, *Guidelines for Urban Major Street Design - A Recommended Practice*, Institute of Transportation Engineers, Washington, D.C., 1984, pp. 22 and 55; American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1990, pp. 349, 437-438, 443-444, 484, 486-487, 531, and 534; Residential Streets Task Force, *Residential Streets*, American Society of Civil Engineers/National Association of Home Builders/Urban Land Institute, Washington, D.C., 1990, pp. 57, 59, and 62-66; ITE Technical Council Committee 5A-25A, *Guidelines for Residential Subdivision Street Design - A Recommended Practice*, Institute of Transportation Engineers (ITE), Washington, D.C., 1993, pp. 6-8 and 13; and Florida Department of Transportation (FDOT), *Manual of Uniform Minimum Standards for Design, Construction, and Maintenance for Streets and Highways (The Green Book)*, Tallahassee, 1994, pp. III-38 and III-39.

Street-Oriented Buildings

The growing dominance of the automobile has been accompanied by changes in architecture and site planning that cause buildings to relate poorly to streets. Buildings have spread out rather than up, stepped back from the street, and had their windows and doors reduced in number, reoriented away from the street, or glazed over.

These changes have minimal effect on motorists as they whiz by. But pity the poor pedestrian who has less to look at, feels more isolated, and has further to go to reach any destination. Important urban design qualities have been lost in the process, including accessibility, safety, enclosure, and transparency. A fourth change

in building design—the increased mass of buildings as viewed from the street (that is, the increased width and sometimes height)—is less destructive to the streetscape and so is dealt with later, as a secondary feature of pedestrian-friendly design.

As we described auto-induced changes in building design and siting, readers may have pictured suburban office buildings in park-like settings or inward-oriented shopping malls surrounding by parking. But the same influences have been at work in residential areas.⁵⁴ With suburbanization, houses first moved back from the street and assumed ranch home proportions. Later, as the price of improved land forced the downsizing of lots, houses moved closer to the street again and assumed narrower/deeper pro-

portions. This time, however, houses approached the street garage-first. Elements that had once linked houses to the street—not only windows and doors but walks, porches, stoops, bays, and balconies—were discarded.

As a convenient rule of thumb, buildings should be set back no farther than 25 feet from the street edge, for beyond that they lose their tangible connection to the street.⁵⁵ Ideally, buildings will be flush with the sidewalk or set back just far enough for a modest yard, forecourt, or landscaped area in front. Surface parking will be to the side or rear of buildings; parked cars should not dominate the streetscape by projecting beyond adjacent building fronts. If any off-street parking is allowed in front, and it is best not to allow any, it should be no deeper than a row or two.

Street for Automobiles with Parking in Front



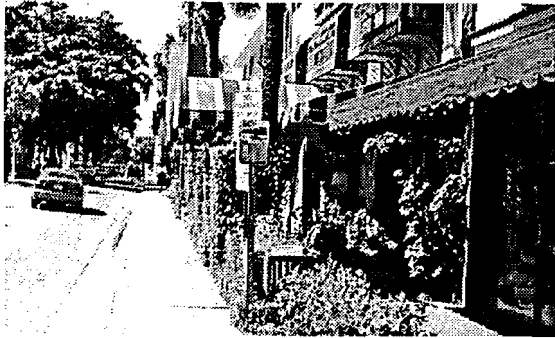
Street for Pedestrians with Parking in Back



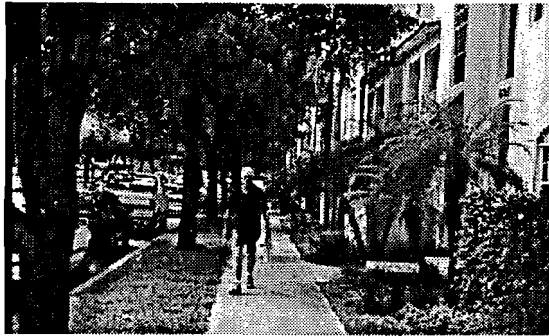
Source: Denver Regional Council of Governments, *Suburban Mobility Design Manual*, Denver, CO, 1993, p. 29.

Strong Connections to the Street Thanks to Small Setbacks and Building Projections

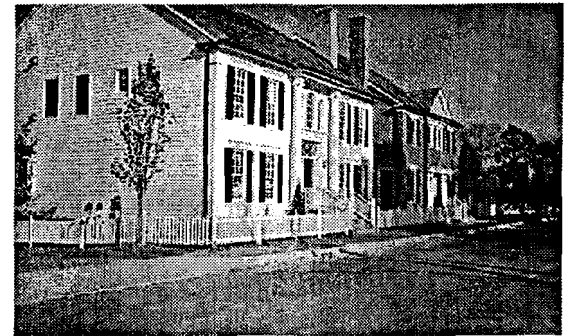
Ft. Lauderdale



Miami Lakes

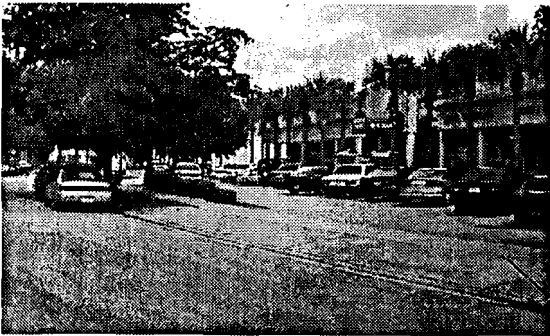


The Kentlands (Gaithersburg, MD)



More-than-Adequate Connections to the Street

Miami Lakes



Mount Dora



Montgomery Village, MD

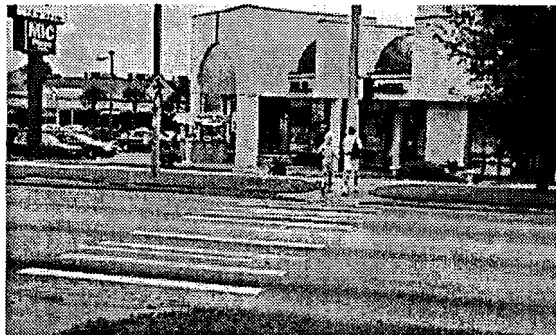


Still Somewhat Connected Despite Auto Orientation

Palo Alto, CA



Orlando

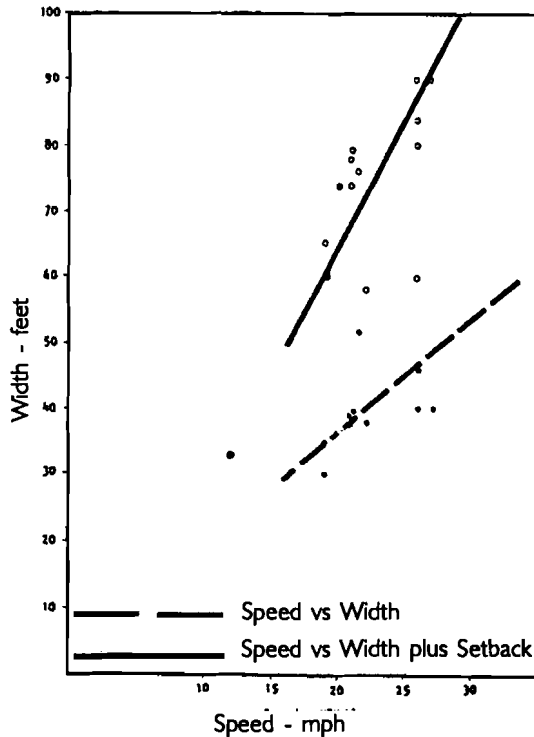


Hollywood



By making a street more room-like, we also make it more pedestrian-friendly. People like rooms. They relate to them daily in their homes and work places, and feel comfortable and secure in them. Drivers respond to the sense of enclosure by slowing down, making the street that much more pedestrian-friendly.⁵⁶

Travel Speed vs. Street Width Plus Setbacks



Source: D.T. Smith and D. Appleyard, "Studies of Speed and Volume on Residential Streets," *Improving the Residential Street Environment*, Federal Highway Administration, Washington, D.C., 1981, pp. 127.

The experts disagree on exactly what height-to-width ratio is desirable for a sense of enclosure and intensely experienced three-dimensional space (see table). A common rule of thumb is that viewers should never be farther away from the defining street edge than three times the enclosure height; this implies a minimum height-to-width ratio of 1:3.

Height-to-Width Ratios for Street Enclosure

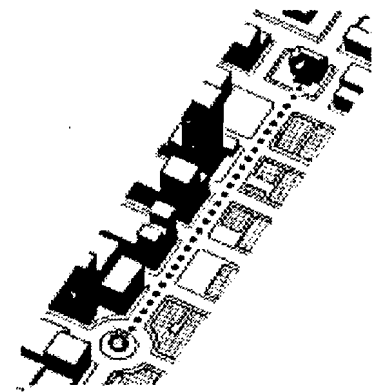
Alexander et al.	1:1 ideal
Lynch and Hack	1:4 minimum 1:2 - 1:3 ideal
Hedman	1:1 - 1:2 ideal
Duany and Plater-Zyberk	1:6 minimum
A. Jacobs	1:2 minimum 1:1 ideal

Sources: C. Alexander, S. Ishikawa, and M. Silverstein, *A Pattern Language - Towns □ Buildings □ Construction*, Oxford University Press, New York, 1977, p. 490; R. Hedman, *Fundamentals of Urban Design*, American Planning Association, Chicago, IL, 1984, pp. 58-59; K. Lynch and G. Hack, *Site Planning*, MIT Press, Cambridge, MA, 1984, p. 158; A. Duany and E. Plater-Zyberk, "The Second Coming of the American Small Town," *Wilson Quarterly*, Vol. 16, 1992, pp. 19-48; and A.B. Jacobs, *Great Streets*, MIT Press, Cambridge, MA, 1993, p. 280.

If we take a residential street with a 30-foot right-of-way and place 20-foot high dwellings along it (spaced side-by-side to create a continuous streetscape), the maximum front setback for a 1:3 height-to-width ratio is 15 feet. If we take a commercial street with 60-foot right-of-way and place 20-foot storefronts along it, they must sit directly on the right-of-way line.

As streets get wider, bordering buildings must rise to contain street space; at some point, even tall buildings will not do the job. Street trees must take over as imperfect substitutes (see "Closely Spaced Shade Trees Along Access Routes," part of the section that follows). Or street vistas must be terminated by strong markers such as monuments or prominent buildings; spatial definition is thus achieved by means of focal points rather than enclosure (see "Lovable Objects, Especially Public Art," part of the section after next).

Focal Points at Ends Compensating for Weakly Defined Street Space

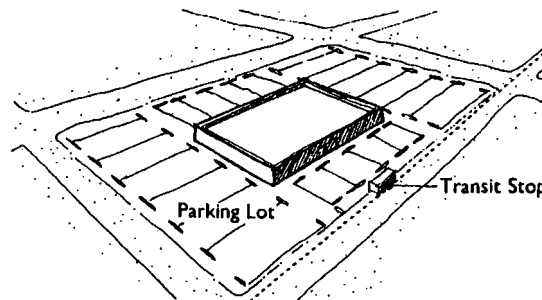


Source: J.B. Goldstein and C.D. Elliott, *Designing America: Creating Urban Identity*, Van Nostrand Reinhold, New York, 1994, p. 171.

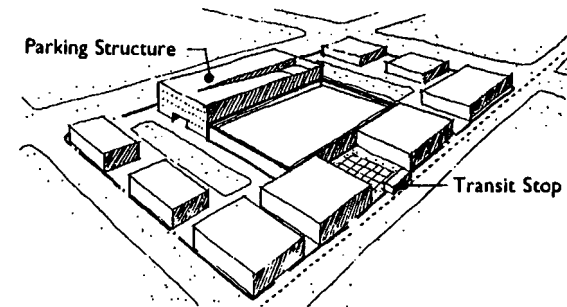
The other requirement for street-oriented buildings is that main entries face the street, and windows, in significant numbers, be at eye level. For security and transparency, buildings cannot turn their backs or blank sides to the street.⁵⁷ The best streets are replete with doors and windows.⁵⁸

This plea for street-oriented buildings does not preclude stores set back from the street in suburban shopping centers, nor office towers set back behind urban plazas, nor any similar building arrangements. It simply means that in such cases, outbuildings must be placed along the street to create positive corners and reasonably continuous streetscapes. Even regional shopping malls with inner courtyard space can be designed with street orientation. Malls can extend to the street on one or more sides, stores can have separate entrances and display areas facing the street, and if necessary, service corridors and loading docks can be provided within the mall itself.⁵⁹

Mall Intensified through the Addition of Outbuildings



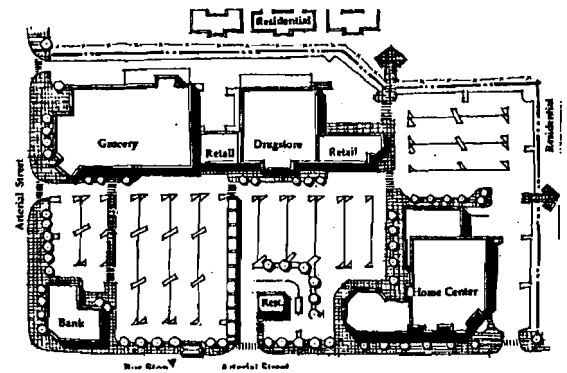
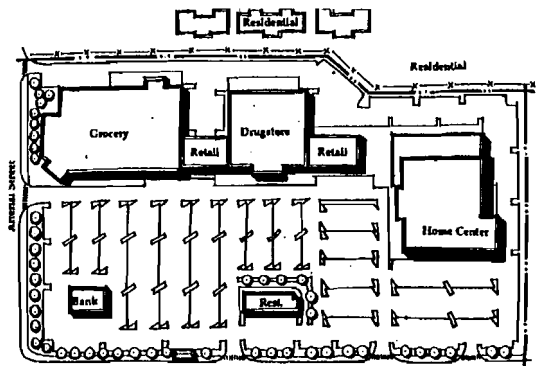
EXISTING SURFACE PARKING LOT



FUTURE INTENSIFICATION

Source: P. Calthorpe, *The Next American Metropolis - Ecology, Community, and the American Dream*, Princeton Architectural Press, New York, 1993, p. 111.

Shopping Center Redesigned to Connect to the Street



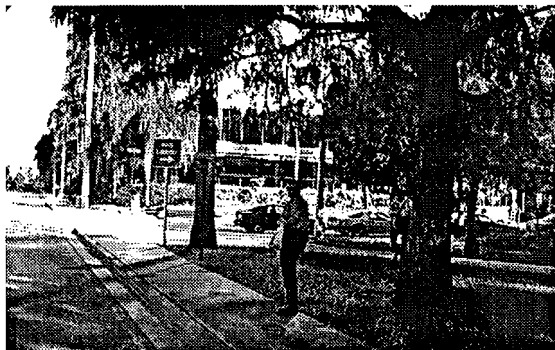
Source: Snohomish County Transportation Authority, *A Guide to Land Use and Public Transportation—Volume II: Applying the Concepts*, Lynnwood, WA, 1993, pp. 2-2 and 2-3.

Comfortable and Safe Places to Wait

With long headways typical of Florida transit systems, transit users must be afforded comfortable and safe places to wait. Comfort has two elements, seating and weather protection. Safety also has two, safety from crime and from traffic.

Let's first consider comfort. In our visual preference survey, having a shelter at a bus stop proved the most important determinant of bus stop selection and rating (Appendix A). Shade from trees or building overhangs, and the pres-

Pretty But Uninviting for Lack of Shade or Seating (Ft. Lauderdale)

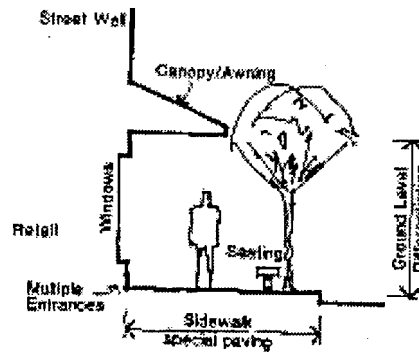


ence of a bench (absent a shelter), were also significant.

Where buildings are close to the street, they can and should be designed for weather protection. Canopies, awnings, and arcades are standard fare in urban design manuals. They protect transit users as well as pedestrians. Benches along the street are also standard, and they too serve both groups.

Where buildings are removed from the street, seating and weather protection must be provided via shelters, bus benches, and tree cover. Bus stops in Florida cities are spaced close together, often as close as every city block. This precludes having shelters or benches at each and every stop. In its TOD manuals, Orlando distinguishes between lo-

Seating and Weather Protection Encouraged in Design Manuals

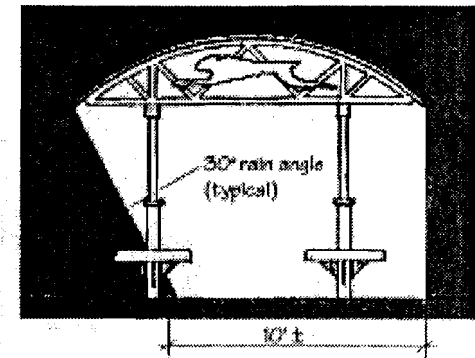


Source: City of Bellevue, Wash., *Design Guidelines - Building/Sidewalk Relationships*, 1983, p. 14.

cal stops and primary local stops. The primary local stops are to be equipped with shelters, benches, and fare and schedule information. If primary stops (by whatever name) are located every quarter to half mile along a route, most users will have access to sheltered stops if they are willing to walk two or three extra minutes.

As for safety, let's first consider crime. The field of crime prevention through environmental design (CPTED) emphasizes natural surveillance.⁶⁰ Bus stops should be clearly visible from travel lanes and nearby buildings; shelter designs should be open enough to afford such visibility; and street lighting should be provided at all stops since good lighting augments every pair of eyes on the street, making them count for more by increasing their range.

Shelter Design That Provides Both Visibility and Protection from the Rain



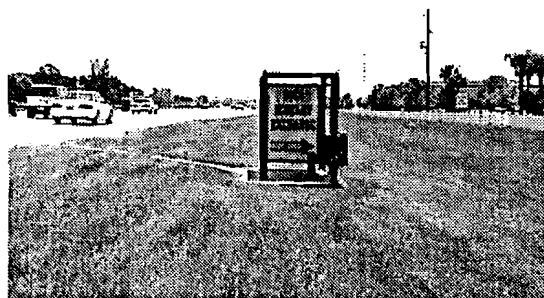
Source: Herbert - Halback, Inc., *Lynx - Customer Amenities Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 5.11.

Equally important is safety from traffic. In our visual preference survey, the presence of a vertical curb and a significant setback from the street edge both proved significant. A barrier-type curb and a significant setback serve as buffers, both physically and psychologically. The two features interact, in the sense that a larger setback is required in the absence of a curb.

*Too Little Setback
(high-speed road with a curb)*



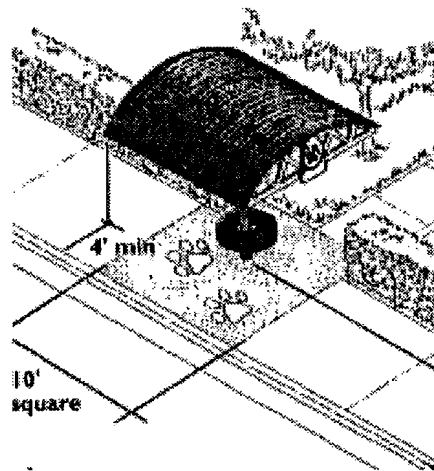
*Too Little Setback
(high-speed road without a curb)*



FDOT recommends that bus benches be set back 10 feet from travel lanes to minimize “discomfort from traffic” for transit users.⁶¹ While a good default value, a 10-foot setback is not always feasible in urban settings, and may not be necessary if traffic speeds and volumes are moderate and streets have vertical curbs. Conversely, in suburban settings, with high design speeds and curbless profiles, a 10-foot setback may not be large enough to give transit users a complete sense of security.

Clearance standards reported in “Appropriate Buffering from Traffic” represent lower limits on bus stop setbacks. Surely, transit users deserve as much protection from runaway motorists as runaway motorists deserve from fixed objects.

*Adequate Shelter Setback
on a Low-Speed Urban Street*



Source: Glattig Jackson Kercher Anglin Lopez Rinehart, Inc., *Central Florida Mobility Design Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 6-7.

Highly Desirables

Supportive Commercial Uses

TOD manuals sometimes seek to classify land uses as either inherently auto-oriented or potentially transit-oriented. Once classified, the idea is to channel the transit-oriented uses into the areas around transit stops and stations, while restricting the auto-oriented uses to areas that

cannot be efficiently served by transit. It is a good idea, as far as it goes.

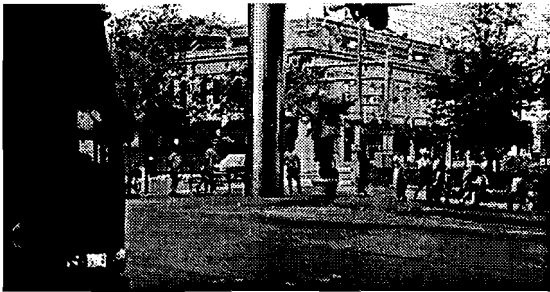
The rub lies in so classifying land uses. Most auto-oriented land uses can be tamed through clever site planning and building design. We have all seen fast-food restaurants and convenience stores that blend into traditional settings. Small setbacks, on-street or rear parking, wall-mounted signs, and compatible architecture make them almost indistinguishable from neigh-

boring shops. A recent report by the Townscape Institute contains dozens of examples.⁶²

Other auto-oriented uses—discount department stores, warehouse clubs, and home improvement centers—have building masses and parking requirements that are harder to work with. Yet, communities have won concessions when they were willing to turn these uses away. They have made “big-box” retailers part of centers rather than strips, reduced their floor areas, required doors and windows on their facades, made their architecture less boxy, and broken up their parking areas. A recent report by the National Trust for Historic Preservation provides many examples.⁶³ Also see related sections of this manual: “Street-Oriented Buildings,” “Not Much ‘Dead’ Space (or Visible Parking),” and “Small-Scale Buildings (or Articulated Larger Ones).”

Inherently Transit-Oriented Uses (Orlando)

Tourist Attraction



Voc-Ed



Fast Food in Miami Beach



Auto-Oriented Uses That Blend In Convenience Store in Davis, CA



Discount Store in West Boca Raton



Examples of transit- and auto-oriented land uses, from three TOD manuals, are presented in the accompanying table. Anomalies and inconsistencies appear in the three lists.

Perhaps a better way to distinguish between auto- and transit-oriented uses is on the basis of performance standards. For example, the uses we generally think of as excessively auto-oriented fall toward the lower

end of the “employees per 1,000 square feet of gross floor area” range (see table). If performance standards related to space per employee, floor-area ratio, parking ratio, or something similar can be met, even nominally auto-oriented uses should be allowed within transit-served areas. Conversely, if standards are not met, even nominally transit-oriented uses should be restricted to other areas. This seems more reasonable and defensible than a blanket exclusion of certain land uses and blanket inclusion of others.

Previous Attempts to Classify Land Uses

	Inherently Auto-Oriented	Potentially Transit-Oriented
Snohomish County Transportation Authority	Motels Elementary Schools Real Estate Offices Large Retail Stores (over 5,000 square feet) Veterinary Clinics	Hotels Day Care Centers Financial Institutions Movie Theatres Government Offices Churches
Beimborn and Rabinowitz (Urban Mass Transportation Administration)	Light Industrial Resort Hotels Specialty Retail Centers Day Care Centers Clinics Government Offices Churches	Heavy Industrial Hotels (outside CBD) Shopping Centers Elementary Schools Hospitals Office Parks
Tri-Met (Portland, OR)	Residential Care Food and Beverage Sales Animal Boarding Motels Banks w/ Drive-Up Services Entertainment Facilities	Emergency Health Care Eating and Drinking Estab. Animal Sales and Services Bed and Breakfast Inns Banks Government Offices

Sources: Snohomish County Transportation Authority, *A Guide to Land Use and Public Transportation for Snohomish County*, Washington, Lynnwood, WA, 1989, pp. 3-8 and 3-9; E. Beimborn and H. Rabinowitz, *Guidelines for Transit Sensitive Land Use Design*, Technology Sharing Program, U.S. Department of Transportation, Washington, D.C., 1991, pp. 141-145; and Tri-County Metropolitan Transportation District of Oregon (Tri-Met), *Planning & Design for Transit*, Portland, OR, 1993, pp. 108-109.

Employee Space Requirements of Different Land Uses

Land Use	Employees/ 1,000 Sq Ft GFA
Sitdown Restaurant	9.92
Medical-Dental Office Building	4.83
Government Office Building	4.29
Bank (Drive-in)	3.64
General Office Building	3.29
Hospital	3.25
Day Care Center	2.39
Manufacturing Plant	1.87
Discount Store	1.53
Tire Store	1.02
Hardware Store	0.96
Furniture Store	0.36

Source: Institute of Transportation Engineers (ITE), *Trip Generation*, Washington, D.C., 1991.

Grid-like Street Networks

The traditional street grid has several advantages for pedestrians. It offers relatively direct routes (compared to a contemporary network with curving streets and cul-de-sacs). It offers alternatives to travel along high-volume routes (since continuous side streets exist in a grid). It is legible, that is, it gives pedestrians a clear sense of orientation.

The traditional grid is actively promoted in many transit-oriented development manuals. It allows transit vehicles to avoid backtracking and frequent turns, and offers transit users direct access to transit stops.

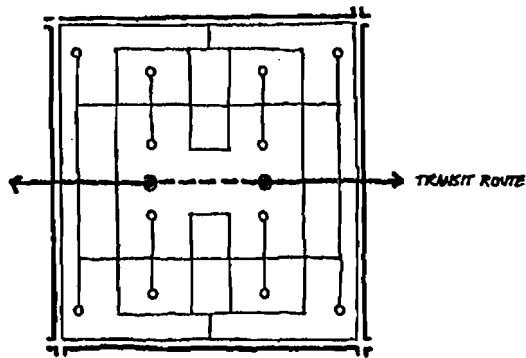
The grid also has disadvantages, mainly related to safety and aesthetics. Advantages and disadvantages are reviewed in *Best Development Practices*, a companion to this manual. Looking at all the evidence, *Best Development Practices* recommends hybrid networks.

We are not alone in this recommendation. At least since the early 1960s, planners have been on a quest for networks would combine the mobility of the grid with the safety, security, and topographic sensitivity of curvilinear streets. *Christopher Tunnard* and *Boris Pushkarev* in their classic, *Man-Made America—Chaos or Control?*, argued that hybrid networks can have an order to them that is easily perceived by

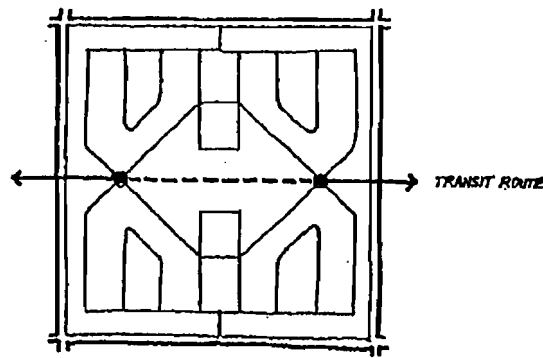
travelers, but an order that is not simple, mechanistic, and monotonous like a grid's. It is a complex order ("variety within unity," as they put it) that affords the best possible aesthetics.⁶⁵

Tunnard and Pushkarev called for a "supergrid" of arterials and collectors that would provide order and orientation—as well as mobility. Local streets could be curvilinear yet orderly in their curves and end points. Such supergrids have become common in suburban America. Though not dense enough to meet transit access standards (see "Transit Routes Every Half-Mile," in the preceding section), they serve transit well in other respects.

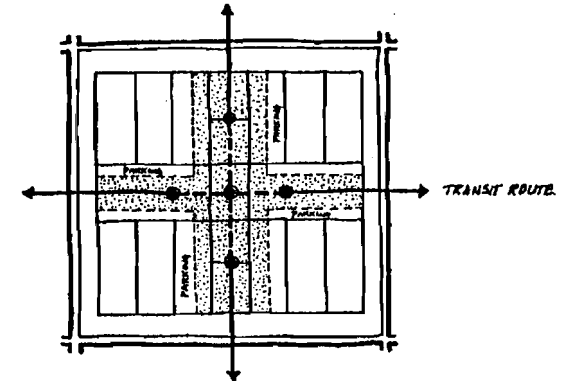
Variations on a Supergrid



VARIATION B
GRID WITH CUL-DE-SACS



VARIATION D
RISE OF INTERNAL PARCEL STREETS



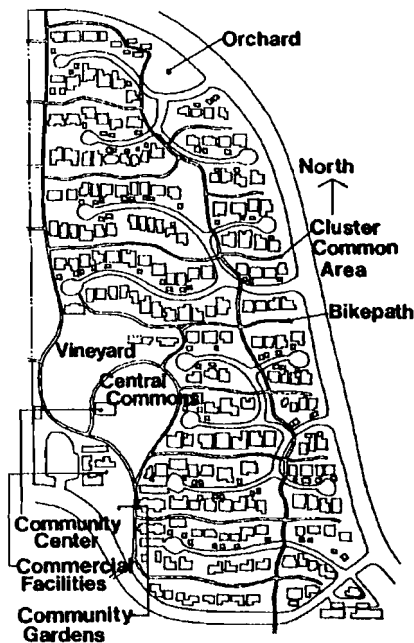
VARIATION F
COMMERCIAL DISTRICT AT THE INTERSECTION
OF TWO TRANSIT CORRIDORS

Source: E. Beimbom and H. Rabinowitz, *Guidelines for Transit Sensitive Land Use Design*, Technology Sharing Program, U.S. Department of Transportation, Washington, D.C., 1991, pp. 112, 114, and 115.

Less common are discontinuous but orderly local street patterns within a supergrid. Examples of the latter are found in several highly acclaimed developments, including Peter Calthorpe's Laguna West, Peter Brown's Four Mile Creek, and Michael Corbett's Village Homes.

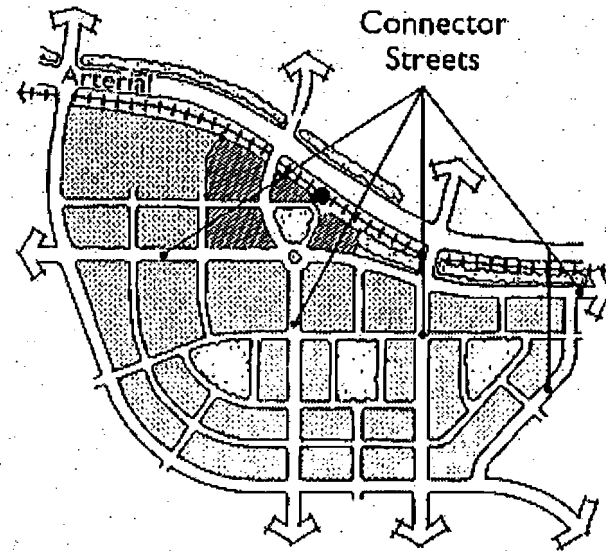
Serving a hybrid network, rather than a complete grid, may have little effect on transit ridership. Our empirical studies of Appendices B and C could find no relationship between transit ridership and street network design, after controlling for other variables such as urban density and transit service frequency.

*Master Plan for Village Homes
(Davis, CA)*



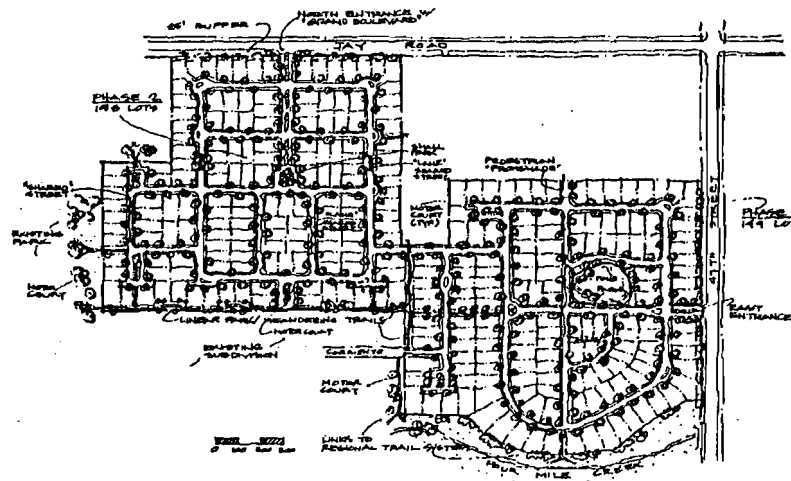
Source: J. Zanetto, "Master Planning," In E.G. McPherson (ed.), *Energy-Conserving Site Design*, American Society of Landscape Architects, Washington, D.C., 1984, pp. 87-114.

Orderly Pattern of "Connector" Streets within a Transit-Oriented Development



Source: P Calthorpe, *The Next American Metropolis - Ecology, Community, and the American Dream*, Princeton Architectural Press, New York, 1993, p. 99.

Master Plan for Four Mile Creek (Boulder, CO)



Source: P Brown, "The Economics of Traditional Neighborhoods: Competing for the Bottom Line with Conventional Subdivisions—A Case Study of Four Mile Creek," *Land Development*, Vol. 6, Fall 1993, pp.20-24.

Traffic Calming Along Access Routes

The street environment suffers greatly as traffic volumes and speeds increase.⁶⁶ A line of parked cars can act as a buffer, as can a row of street trees or street lights. If nothing else, sidewalks can be set back some distance from the street. But, even with a buffer, no sidewalk will be inviting to pedestrians if it sits next to a high-speed, high-volume thoroughfare.

Traffic calming, a term coined in Europe, popularized in Britain and Australia, and recently imported to the U.S., is accomplished through measures that control the volume of traffic, speed of

traffic, or both. While most measures have some effect on both volume and speed, they are usually classified according to their dominant effect. Street closures, restrictive one-way street patterns, diverters at intersections, and turn restrictions are primarily volume control measures. Speed humps, traffic circles, sharp bends and chicanes (S-curves), and narrowings at midblock or at intersections are primarily speed control measures. Based on dozens of engineering studies, the effects of different measures can be compared and contrasted schematically (as below).⁶⁷

In the U.S., we rely on volume controls to "calm" traffic on our residential streets. In the sub-

urbs, streets form branching patterns until they dead-end in cul-de-sacs that serve only local traffic. Or they loop around on themselves or curve endlessly to discourage all but local traffic. Meanwhile, our arterials and collectors are asked to carry ever-increasing volumes, this due to loss of carrying capacity on local streets.

The Europeans, and recently the British, have placed their emphasis on speed controls.⁶⁸ Rather than excluding through-traffic from local streets, they have sought to calm it by slowing it down. They have taken this approach because the alternative—U.S.-style traffic calming—adds long detours to access trips and adds congestion to the few remaining through-streets. Some European countries have even extended traffic calming to major thoroughfares in the interest of pedestrian- and transit-friendliness.

In the European version of traffic calming, the goal is to keep traffic moving but always moving at speeds appropriate to the setting:

- 15 km/h or 9 mph on *Woonerven* and other shared surface streets in Holland and other northern European countries;

- 30 km/h or 19 mph on *Stille veje* and other quiet streets in Denmark and elsewhere all over Europe and Britain;

- 50 km/h or 31 mph on traffic-calmed arterials, mainly in Germany but also in Italy and Japan; and

Effects of Traffic Calming Measures

<i>Measure</i>	<i>Effect on Volumes</i>	<i>Effect on Speeds</i>
Diverters/Semi-Diverters	↓↓	↓
One-Way Streets	↓↓	↑
Speed Humps (standard profiles)	↓↓	↓↓
Speed Tables (long flat-topped speed humps)	↓	↓↓
Narrowings/Throttles	—	↓
Chicanes/Staggerings	—	↓↓
Traffic Circles/Roundabouts	—	↓↓
Narrow Lanes	—	↓
Speed Zones	—	—

↓↓ Large Reduction (typically over 25%) — No Significant Effect
 ↓ Small Reduction ↑ Small Increase

Sources: See endnote 67.

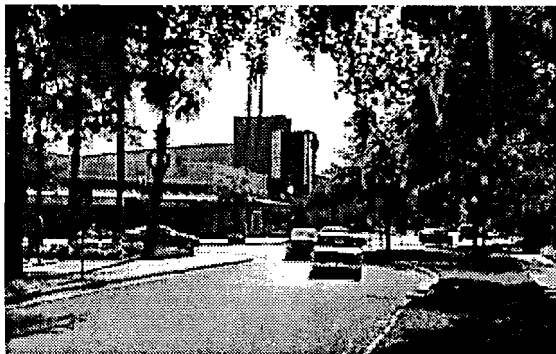
· 40-50 km (25-31 mph) on intercity roads as they cut through rural villages, mainly in Denmark and France.

The engineering and nonengineering measures used to achieve these design speeds are described in a companion document, *Best Development Practices*. These measures have proven successful in significantly slowing down traffic, reducing accidents, and generating more pedestrian and bicycle traffic.

It is tempting to include European traffic calming among the “essential” features of pedestrian- and transit-friendly environments. We hesitate only because there are so few genuine examples in the U.S., beyond the occasional main street improvement project. A string of recent U.S. publications should raise awareness of the many possibilities; one source went so far as to call traffic calming the “most significant new idea in city planning in the last 30 years.”⁶⁹

Note that European traffic calming does not preclude high-volume, high-speed thoroughfares linking different communities and districts within our urban areas. It simply ensures that within communities and districts, streets will act as a unifying rather than dividing force. Or put another way, “roads” are fine elsewhere, but within communities and districts, all public ways should be designed to function as “streets” (with all that term implies).

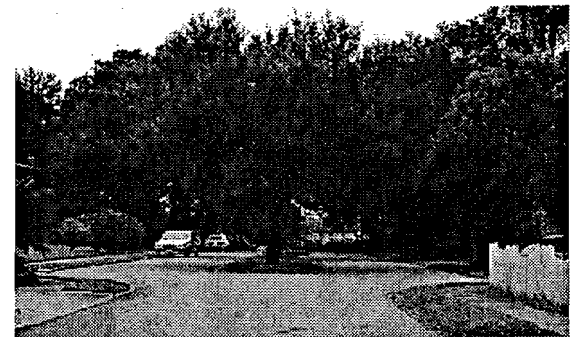
Jog (Tampa)



Modest Traffic Calming Devices
Speed Hump (Palo Alto, CA)



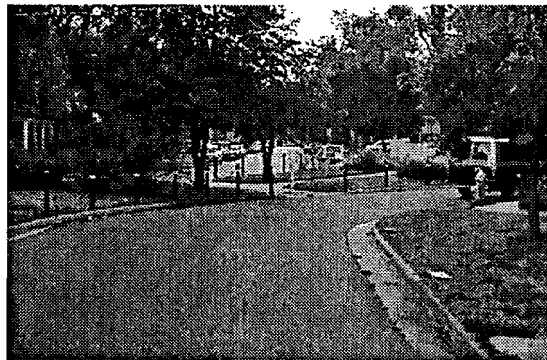
Center Island (Winter Park)



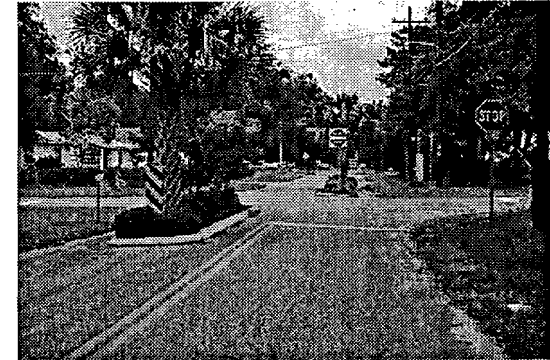
Chicane (Alachua)



Diverter (Boulder, CO)



Semi-Diverter (Gainesville)



Closely Spaced Shade Trees Along Access Routes

If the "right" trees are planted in the "right" patterns at the "right" locations, they contribute to nearly all pedestrian-friendly design objectives. Generally speaking, the "right" trees are shade trees that will grow to 50 to 70 feet at maturity and have a canopy starting at a comfortable 15 feet or so above the ground. On a bioclimatic chart for a place like Miami, the combination of temperature and humidity for most of the year puts us above the "shading line," where shade is always required, and wind often required, for outdoor comfort.⁷⁰ The constant movement of branches and leaves, and the ever-changing patterns of light created, add to the visual complexity of the streetscape. The low

Orderly Arrangement of Trees for Linkage and Sense of Place

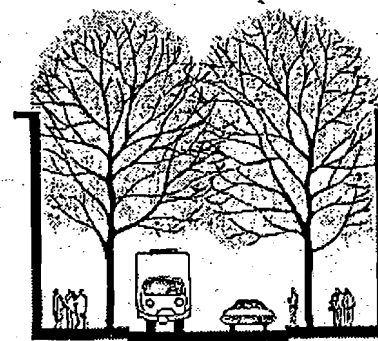


Source: H. Arnold, *Trees in Urban Design*, Van Nostrand Reinhold, New York, 1993, p. 73.

canopy contrasts with the monumentality of wide spaces and tall buildings, creating human scale within larger volumes.

The "right" pattern of trees places them close enough together to form a continuous canopy over the sidewalk. This requires spacing of 30 feet or less center-to-center, not the 50 to 70 feet called for in land

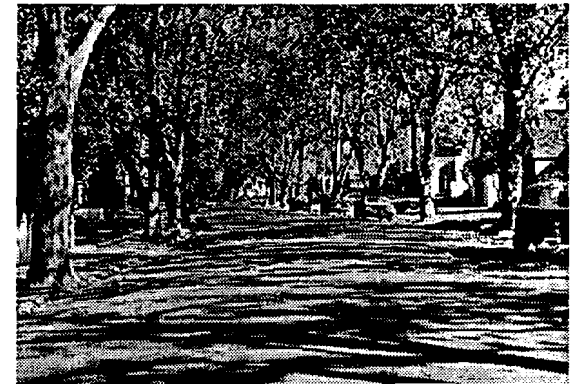
Spatial Definition with Large vs. Small Street Trees



Source: H. Arnold, *Trees in Urban Design*, Van Nostrand Reinhold, New York, 1993, p. 58.

development codes. When trees are first planted, they must be close together to define street space at all. As they mature over decades, closely spaced trees will have higher, more translucent canopies that produce an

Ever-Changing Light Patterns (San Jose, CA)



Mediating Scale of High-Rise Offices (Miami)



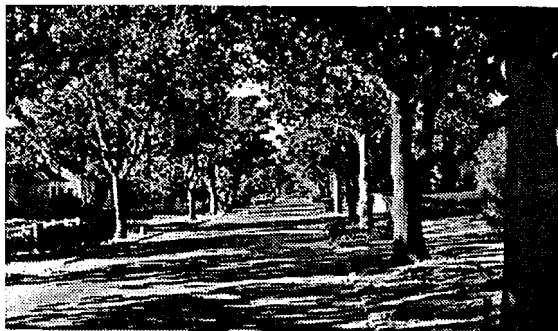
uninterrupted quality of light and shade. Streets cited as outstanding examples by *Henry Arnold* in his insightful book, *Trees in Urban Design*, nearly all have shade trees no more than 30 feet apart.⁷¹

The “right” location for street trees is between the street and sidewalk, as close to the curb as engineering standards permit (see “Appropriate Buffering from Traffic”). Trees planted between the street and sidewalk provide a physical and psychological barrier between large-mass vehicles and small-mass pedestrians. In this location, trees

*Street Trees Spaced
Less Than 30 Feet Apart
Jacksonville*



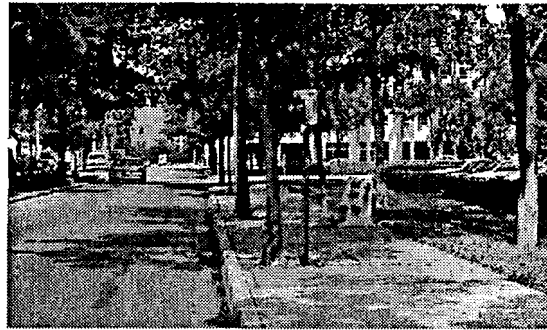
Palo Alto, CA



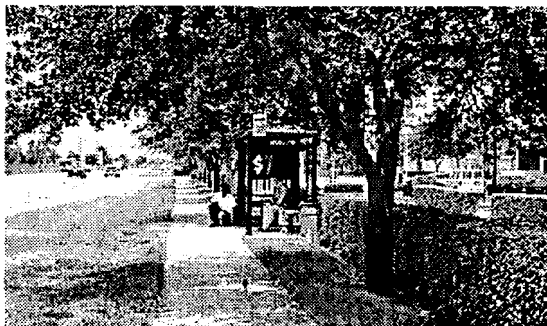
visually limit street space, thereby calming traffic; they extend pedestrian space from buildings to the street; and they shade the entire right-of-way, both street and sidewalk.⁷²

The standard suburban practice is just the opposite of what is recommended here. Small ornamental and flowering trees, fruit trees, palms, and evergreens usually substitute for substantial shade trees. They are placed far apart and set on the far side of the sidewalk close to the right-of-way line, where they pose less risk to errant vehicles. Used

*Tree Row Expanding Pedestrians'
Psychological Space*



*Tree Row Expanding Motorists'
Psychological Space*



in these ways, trees may decorate a street or screen an unpleasant view, but they contribute little to the fundamentals of good design—such qualities as spatial definition and pedestrian safety.

As with traffic calming, it is tempting to label closely spaced shade trees an essential feature of pedestrian- and transit-friendly streets, particularly in the Sunshine state with its high temperatures and high humidity. Yet, as with traffic calming, it seems unreasonable to label any feature “essential” that hardly exists in the United States. This applies doubly to our central cities, the areas we now consider most pedestrian- and transit-friendly. When it comes to trees, cities are more deficient than suburbs, which themselves are often terribly deficient.⁷³

Perhaps this is why transit ridership proves unrelated to the percentage of tree-lined street frontage in our analysis of ridership at sampled bus stops (Appendix C). Indeed, the partial correlation between ridership and tree-lined street frontage is negative (though not at significant levels). At the same time, trees along the street leading to bus stops are the second most highly valued feature in our visual preference survey; shading at stops is significant, too (Appendix A). It appears, then, the lack of relationship between trees and transit use reflects supply (trees are not supplied in transit-served areas), not demand.

Not Much "Dead" Space
(or Visible Parking)

Designers promote active street-level land uses with such fervor that it came as a shock when transit ridership in Dade County was found to increase with the proportion of street frontage devoted to parking and other inactive uses (Appendix C). This particular variable was simply overwhelmed by another variable—the number of people employed nearby. The same employment concentrations that generate many transit trips also generate many auto trips, and require commensurate parking.

Given this finding, minimizing "dead" street frontage was downgraded to the second tier of pedestrian- and transit-friendly features. It is still important, but possibly less so for utilitarian trips than has been assumed.

Parking lots have become the principal source of dead space in cities. No less authority than *William H. Whyte* considers them worse than blank walls.⁷⁴ Parking lots crowd out active uses, leaving people with less reason to come to an area and park in the first place. Empty metal shells and expanses of flat black asphalt are less interesting than almost any building imaginable.

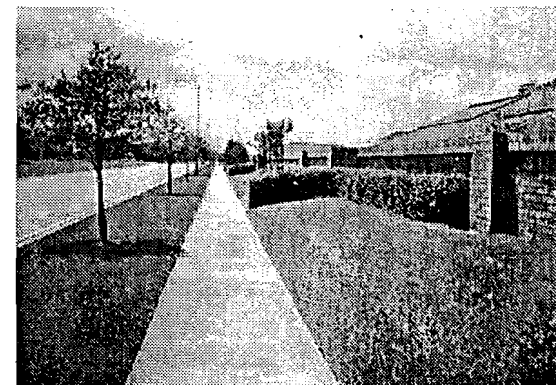
Nine percent (9%) is said to be the upper limit on the amount of land area devoted to parking; beyond that, people sense that the environment is no longer theirs but instead belongs to automobiles.⁷⁵ Downtown pedestrian counts in small cities fall as the amount of open parking increases.⁷⁶

Dead Spaces of Various Sorts

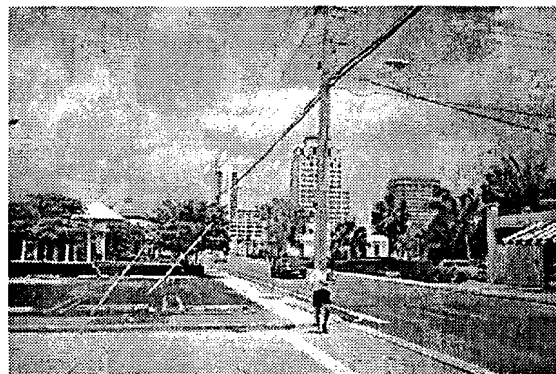
Miami Beach



Hunter's Creek



West Palm Beach



Ft. Lauderdale



None of the "great streets" featured in the book by that name has an abundance of parking, either off street or on.⁷⁷

To meet the 9% target, or come close, it is necessary to:

- set maximums on the amount of parking supplied by developers, not just minimums as in most

land development codes;

- give credit for curbside parking against the amount of off-street parking required;

- reduce the amount of parking required whenever land uses with different parking patterns share parking lots;

- substitute parking garages for surface parking lots; and/or

- build satellite parking facilities to free pedestrian streets from heavy parking demands.

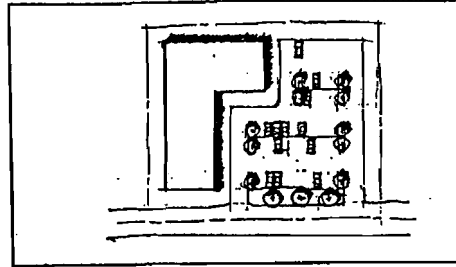
Examples of enlightened parking policies can be found here and there around the State of Florida. Indeed, at least one Florida city, Orlando, has tried all of the above in its downtown. Guidance in devising such policies is available from many sources.⁷⁸

Where surface parking remains after such policies are adopted, it should be placed behind buildings (the best) or to the side (the second best). If placed in front, surface parking should be limited to a row or two to preserve the street orientation of buildings. *Peter Calthorpe* recommends that parking lots occupy no more than 1/3 of the frontage on pedestrian-oriented streets, and no more than 75 feet at a single stretch.⁷⁹ Even these figures may be too high for pedestrian streets.

While parking lots have the potential to be almost park- or plaza-like, it so seldom happens, in practice, that screening parking with walls, hedges, or berms is advisable along public streets. Walls fit well into urban settings. If low and articulated, they form a nice street edge that is both complex and transparent.

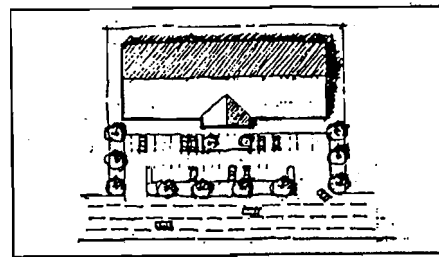
The other major source of dead space in cities is blank walls—windowless or reflective glass building facades, garage-dominated residential streets, and flat security walls. While blank walls

Parking Placed to the Side of Buildings



Source: M.L. Hinshaw and Hough Beck & Baird, Inc., *Design Objectives Plan: Entryway Corridors - Bozeman, Montana, 1992*, p. 43.

Parking Limited to a Row or Two in Front of Buildings



Source: M.L. Hinshaw and Hough Beck & Baird, Inc., *Design Objectives Plan: Entryway Corridors - Bozeman, Montana, 1992*, p. 42.

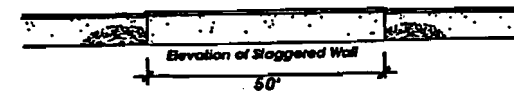
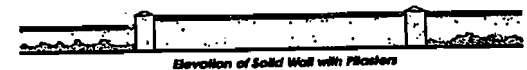
Wall That Screens Parking without Spoiling the Street Edge (Mount Dora)



can define and enclose space, the resulting space is characterless. It takes architectural details, surface textures, modulation of light and shade, or changes in color to inject life into space and hold pedestrian interest.⁸⁰

Whyte has toyed with the idea of calculating a “blank wall index” for urban places, equal the percentage of blank walls up to 35 feet above street-level.⁸¹ If such an index were devised and measured over space and time, it would be high in cities, even higher in suburbs, and on the rise everywhere. Based on New York’s experience, it seems reasonable to expect downtowns to have at least 50% of their ground-floor frontage devoted to retail uses, and all glass fronts to be of the see-through variety.⁸² Where blank walls are unavoidable, they should be articulated and/or softened with plantings.

Articulated and Landscaped Walls and Wall-Fence Combinations

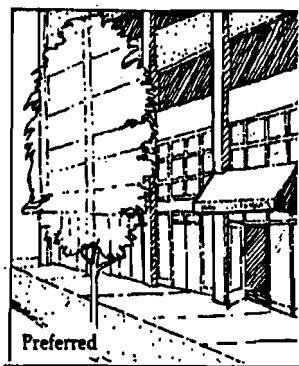
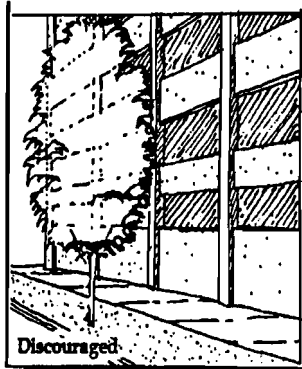


Source: City of San Bernardino, Calif., *Title 19 - City of San Bernardino Municipal Code, 1991*, p. II-145.

◆ II. Checklist of Pedestrian- and Transit Friendly Features ◆

Parking garages, desirable in other respects, add to the blank wall problem of cities. They should be disguised to look like neighboring buildings, with the same proportions of vertical and horizontal elements and with the same building materials. Or they should be hidden behind trees and other landscaping so their appearance becomes less problematic. For added interest, parking garages can have retail outlets at street level or retail display cases.

*Blank Facade of Parking Garage
Redesigned as Retail Space*



Source: Calthorpe Associates, *Transit-Oriented Development Design Guidelines*, Sacramento County, Calif., 1990, p. 68.

Nearby Parks and Other Public Spaces

Like shops, nearby parks and other public spaces (playgrounds, plazas, gardens, squares, etc.) serve as attractions for pedestrians. Walking around the block, or the subdivision, is a poor substitute for a real destination.

Like city sidewalks, public spaces serve as settings for casual social interaction. Lack of "community" in suburban America, a source of so much concern, is in part due to lack of settings for neighborly interaction.

Given these positive functions of nearby spaces, they might be expected to rank within the first tier of pedestrian- and transit-friendly features, along with wide sidewalks and nearby shops (mixed uses). They are placed in the second tier instead because they perform the same functions less well than do sidewalks and nearby shops. That is, public spaces do not hold as much attraction as shops and do not promote causal neighborly interaction as well as sidewalks (not to mention the use of sidewalks to get around).⁸³

Two design principles follow from the above comparison of public spaces, sidewalks, and shops. First, spaces contribute more to the street environment when they appear as extensions of street and sidewalk rather than as stand alones. If a good pedestrian street is an outdoor room, then a good park, playground, or plaza is another room just off the main room, or an alcove within the main room.

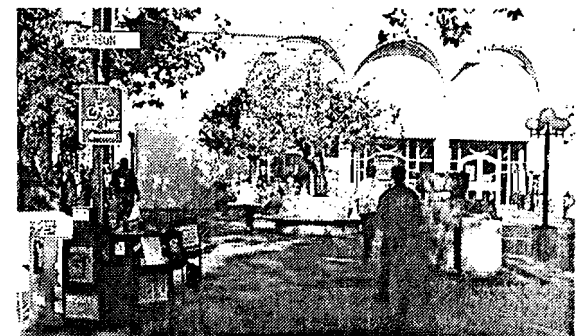
Used in this manner, public spaces punctuate the street network, break up long stretches, and grace streets with beginnings and endings. They give the streets upon which they sit a special character, something lacking in modern street networks.⁸⁴ They add complexity, legibility, and sense of place to the street environment.

*Parks and Plazas
as Extensions of Main Streets*

Winter Park



Palo Alto, CA



William H. Whyte's study of plazas in New York shows just how important connections to the street and sidewalk can be. Well-connected plazas generate a substantial amount of impulse use. Sunken or elevated plazas do not. "If people do not see a space, they will not use it."⁸⁵

The second design principle is that public spaces contribute more to the street environment when they have a variety of land uses nearby rather than drawing on only one use. A single dominant use generates patrons with similar schedules (mothers at mid-afternoon, office workers at lunch time). Spaces are depopulated at other hours. A generalized space, without any particular draw of its own, is populated only where "life swirls" nearby due to the interaction of other land uses.⁸⁶

Shoppers and other visitors animate public spaces, and public spaces in turn cause them to linger. Spaces may be as small as a flared corner or a recessed entry to a building equipped with a bench and shade tree. In fact, some of the most valued and heavily used spaces are the smallest. A hint of crowding may actually enhance their appeal and festive character.

A companion to this manual, *Best Development Practices*, offers design guidelines for parks and other public spaces.⁸⁷ Among them: Spaces should be highly accessible to pedestrians, linked to other spaces via sight lines, and crammed with activities and sensuous el-

ements (trees, water, sculpture, etc.). Illustrations follow.

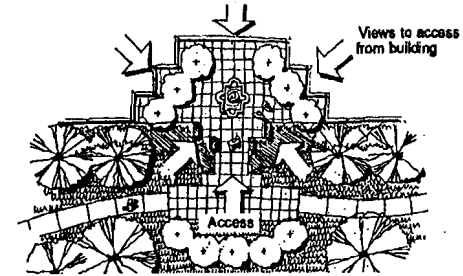
Plaza Built into Conventional Shopping Center (Boca Raton)



Plaza Created by a Flared Sidewalk (Hollywood)

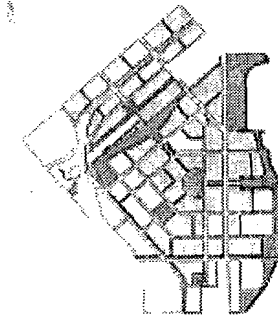


Public Space Accessible from Several Directions



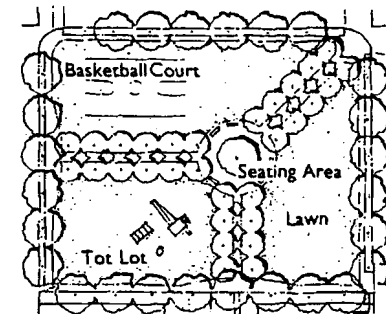
Source: Edward D. Stone, Jr. and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 2.2.

Public Spaces Linked to One Another



Source: City and County of San Francisco, *Mission Bay Plan - Proposal for Adoption*, 1990.

Small Park Supporting Multiple Activities



Source: P. Calthorpe, *The Next American Metropolis - Ecology, Community, and the American Dream*, Princeton Architectural Press, New York, 1993, p. 92.

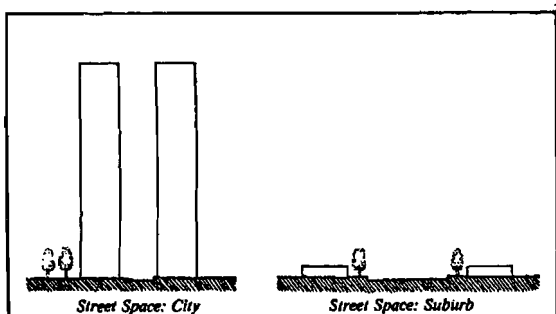
◆ II. Checklist of Pedestrian- and Transit Friendly Features ◆

Small-Scale Buildings (or Articulated Larger Ones)

When designers call for small-scale buildings along public streets, they are referring to scale in two dimensions, vertical and horizontal. In the vertical dimension, buildings should not be so tall as to completely block the pedestrian's cone of vision; street space can become canyon-like. Likewise, buildings should not be so tall as to isolate building occupants from the casual interaction that occurs on the street and sidewalk.

How tall is too tall? One source has set the limit of human scale at three stories, another at four.⁸⁸ At three or four stories, the intersection of building and sky still registers in the pedestrian's peripheral vision. With a slight tilt of the head, the pedestrian can take in an entire building facade. The occupant of the uppermost floor may still feel part of the street scene—see details on the street, call down to

Too High and Too Low



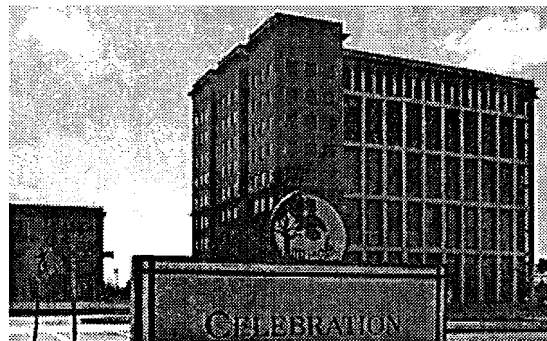
Source: R. Trancik, *Finding Lost Space—Theories of Urban Design*, Van Nostrand Reinhold, New York, 1986, p. 80.

someone, quickly walk down to engage in street activities.⁸⁹

The three- or four-story limit is subject to a caveat. As discussed previously, pedestrians will experience a sense of street enclosure only where buildings are sufficiently tall in relation to street widths. The “great streets” studied by Allan Jacobs include some wide avenues and boulevards. Not coincidentally, these streets are sometimes bounded by tall buildings, as tall as 100 feet.⁹⁰ Given the scale of the streets, this scale of buildings is appropriate. A careful balance must always be maintained between human scale and the scale of the setting.

As for the horizontal dimension of buildings, no simple rule of thumb, like the four-story rule, is available to define small scale. But in traditional urban settings, one thinks of buildings as

Human-Scale Logo vs. Auto-Scale Buildings (Celebration, Orlando)

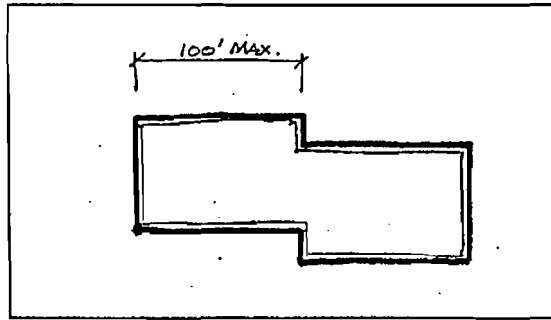


having dominant vertical proportions, that is, being taller than they are wide. This implies building widths of 30 to 100 feet, depending on building heights.

The horizontal dimension of buildings may actually be more important than the vertical. Narrow buildings keep eyes engaged by introducing the work of multiple architects and exposing many building surfaces. They help define street space and subdivide long streets by providing many vertical lines against which scale can be judged. They make the street edge more transparent by increasing the number of entrances facing the street, and usually the number of windows, too. For these reasons, the presence of many narrow buildings along the street is considered, by one very credible source, to be among the five most important qualities for urban livability.⁹¹

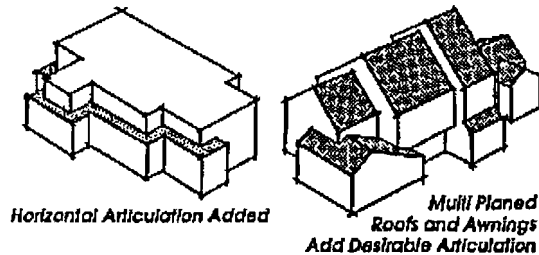
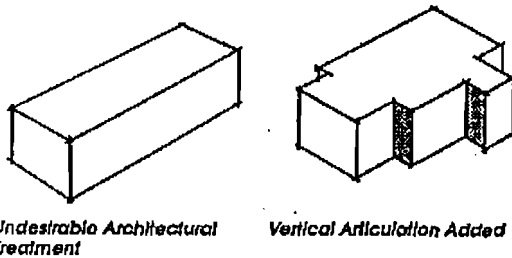
While human-scale buildings are the ideal, large buildings can be made to appear less massive if divided into many smaller forms through articulated architecture. Richard Hedman devotes much of his *Fundamentals of Urban Design* to coping with oversized city buildings.⁹² Changes in exterior materials can disguise the true width of buildings. Cornices and belt courses can moderate the height. Awnings, balconies, clock towers, and other small-scale elements can reduce the apparent mass.

*Long, Flat Facades
Discouraged in Design Manuals*



Source: M.L. Hinshaw and Hough Beck & Baird, Inc., *Design Objectives Plan: Entryway Corridors - Bozeman, Montana, 1992*, p. 22.

*Vertical and Horizontal
Articulation of Large Buildings*



Source: City of San Bernardino, Calif., *Title 19 - City of San Bernardino Municipal Code, 1991*, p. II-40.

Main Street at Miami Lakes is formed out of a few long buildings, with shops below and apartments above. The buildings “read” as many small attached structures due to their projections, angled surfaces, varying roof lines, and recently, facades painted in different but complementary colors. Miami Lakes Town Center and other unified development projects like it have been criticized for lacking the hodge-podge character and social class diversity of real downtowns. But for pure walkability, this place easily beats many real downtowns and real main streets.

*Not Entirely Real But Walkable
(Miami Lakes Town Center)*



*Real But Not Entirely Walkable
(Downtown Jacksonville)*



Where buildings are much taller than ideal for pedestrians, they can be designed as two or more separate building types within the same envelope. For Roger Trancik, “The only way the integrity of street can be preserved in a city of towers is by making clear transitions from high to low building elements.”⁹³ The base can spread out, giving human-scale definition to streets and plazas, while upper floors step back before they ascend. Examples follow.

*Buildings Stepping Back
from the Street*

Mizner Park (Boca Raton)



San Francisco, CA



Classy Looking Transit Facilities

In the quest for efficiency, transit has become dull and utilitarian, part of the problem rather than the solution to today's lifeless streetscapes.⁹⁴ Benches are covered with advertising. Plexiglass shelters project a cheap, second-class image. Some transfer centers and park-and-ride lots are stark to the point of unsightliness. With their dark tinted windows and unbroken horizontal lines, standard transit coaches are mobile versions of the dark, reflective glass buildings that urban designers rail against.

*Second-Class and Unsightly
Jacksonville*



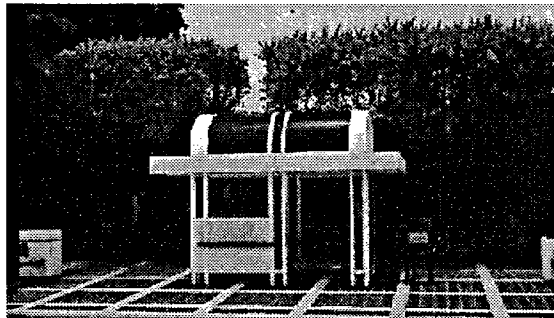
Tampa



Results of our visual preference survey provide insights into what people consider classy, and classless, in transit facilities (Appendix A). In the paired comparison of bus stops, scenes were more likely to be chosen when advertising was absent from benches and shelters. This was true for transit users, nonusers, and transit professionals.

In the separate slide show of bus shelters, higher ratings were given to shelters with some architectural flair, whether by virtue of spacious designs, pitched roofs, or traditional materials

*Darth Vader-like Shelter and Bus
Bal Harbour*

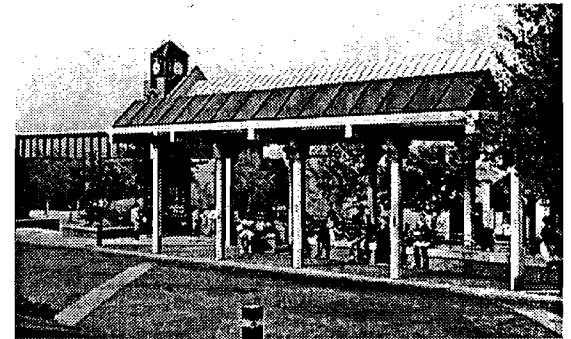


Miami

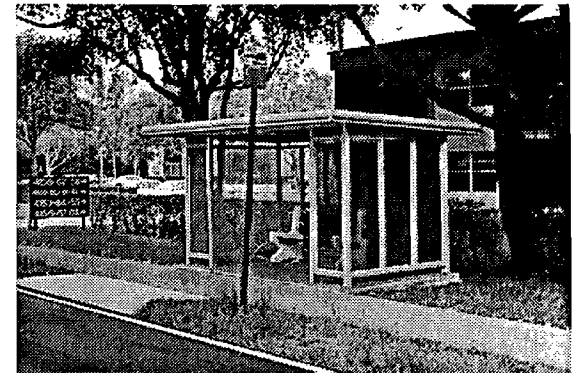


such as brick and metal. Interestingly, transit users seemed to care less about appearances than did transit professionals or nonusers, as indicated by the relative scores given open vs. closed designs (see photos below). At least the closed box-like designs provided weather protection, said transit users in their written explanations for ratings. This is why "Comfortable and Safe Places to Wait" is ranked among the first tier

*Average Scores Assigned to Bus Shelters
(Scale of 1 to 5)*



Users - 3.4 Nonusers - 4.4



Users - 4.0 Nonusers - 2.8

of transit-friendly features, while “Classy Looking Transit Facilities” is assigned to the second.

Rather than being viewed as transportation alone, transit benches, shelters, and even buses should be viewed as items of street furniture. Yes, even buses are street furniture, albeit a mobile variety. They can and should be designed to enhance streetscapes.

Transit Vehicles that Enhance Streetscapes

Orlando



Miami Beach

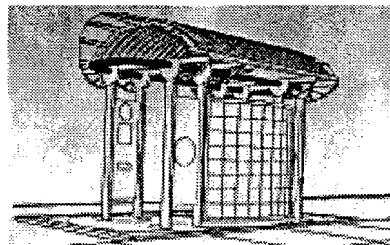


While difficult to prove, it seems that transit operators might do better by putting fewer buses on the street at times of low demand, and diverting the money they save into bus stop amenities and fleet facelifts. Many Florida transit operators are using minibuses and/or rubber-tired trolleys. Several are experimenting with shelters and benches of attractive design. Ft. Lauderdale went so far as to hold a competition for the best bus shelter design; the winning entry has a lot more architectural flare than anything Ft. Lauderdale has seen before.

Tampa Bay's Experimental Shelter















Ft. Lauderdale's Winning Bus Shelter Design



Source: Oscar Vagi and Associates, TMA Express: News from the Downtown Fort Lauderdale Transportation Management Association, Spring, 1995, p. 1.

The potential contributions of transit to urban design are evident in Orlando, where transit stop signs are embossed with the system logo (a LYNX paw), standard transit coaches carry scenes from Orlando's theme parks, minibuses substitute for standard coaches where appropriate, and public art is being introduced at selected stops. Orlando is changing the image of transit by making it (in the operator's words) “Funky... Fun... Artistic... Colorful... Bold... Graphic... Wild... Creative... Cutting Edge!”⁹⁵

LYNX (Orlando) Transit Amenity Matrix

		
Transit Sign	Shelters	Lighting
		
Specialty Paving	System Maps / Fare Schedules	Landscaping
		
Benches	Trash Receptacles	Reader Board and Signaling Devices
		
Leaning Rail	Bicycle Storage	Information Kiosk

Source: Herbert - Halback, Inc., Lynx - Customer Amenities Manual, Central Florida Regional Transportation Authority, Orlando, 1994, p. 1.4.

❖ II. Checklist of Pedestrian- and Transit Friendly Features ❖

Nice Additions

"Streetwalls"

Designers speak of "streetwalls" in almost reverential terms.⁹⁶ A streetwall consists of uninterrupted building facades. Examples include the storefronts along main street of small town America, the row houses of the traditional city, and the picture-postcard streetscapes of European cities.

One attraction of streetwalls is visual enclosure, a pedestrian-friendly quality about which much has been said already. If uninterrupted facades exist on both sides of a street, buildings are of comparable height, and the street is not too wide, observers will perceive the facades as the side walls of an outdoor room, and the sky as an invisible ceiling resting upon them.

*Streetwalls of a Fine European City
(The Hague)*



Another attraction of streetwalls is the clear paths they leave pedestrians on sidewalks. Pedestrians need not dodge, nor worry about dodging, cars turning into or out of individual driveways.

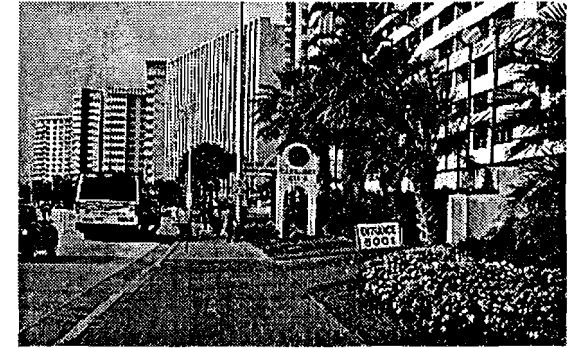
Streetwalls would be higher up the list of pedestrian- and transit-friendly features were it not for two facts. First, in the absence of active street-level uses, streetwalls have no special ability to enliven street space. Second, in the presence of active street-level uses, other building arrangements are just about as good. Regularly spaced detached buildings can have comparable street appeal. Some staggering of setbacks may actually add visual interest. Any traditional neighborhood of porch homes fails the "streetwall" test but certainly qualifies as pedestrian-friendly.

*Streetwalls of a Small American Town
(Sebring)*

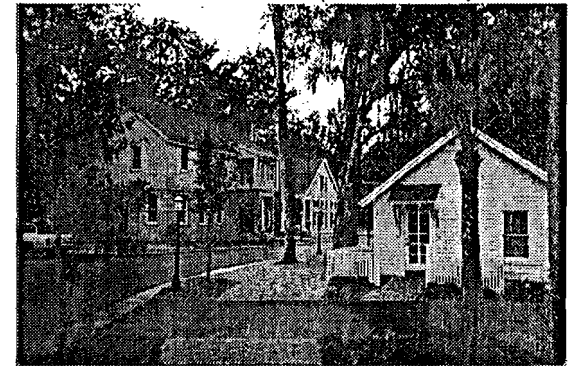


Nice Street Environments without Streetwalls

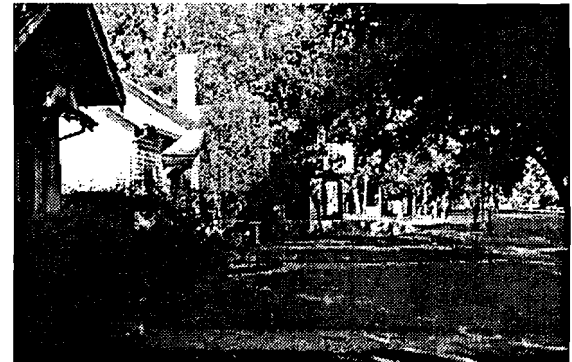
Miami Beach



Haile Plantation (Gainesville)

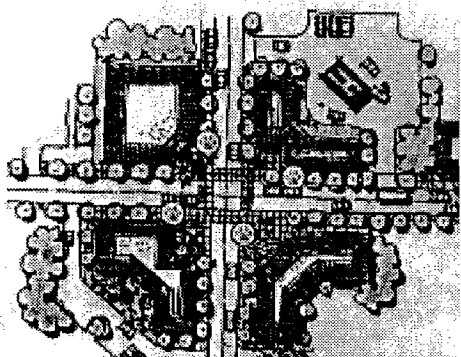


Davis, CA



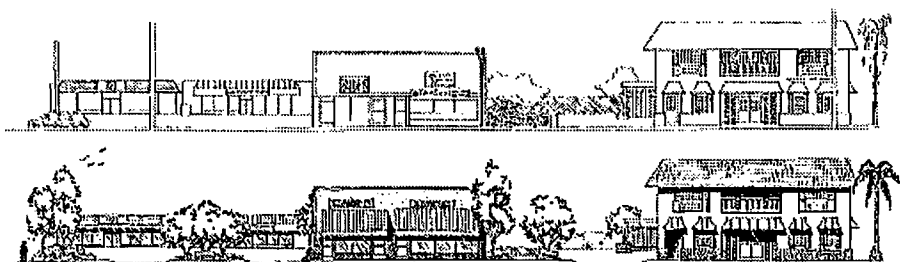
Having opened the door to other building arrangements, it is necessary to screen out arrangements that will not work. Buildings cannot stand too far apart or continuity of the streetscape will be lost. Buildings should edge up to street corners so the corners, at least, become positive spaces. Exposed sides of detached buildings should be as transparent and architecturally interesting as their fronts. Trees should be used liberally along streets with discontinuous buildings to create a virtual street wall. Driveways should be kept to an absolute minimum.

Street Corners Filled with Lively Uses



Source: Glatting Jackson Kercher Anglin Lopez Rinehart, Inc., *Central Florida Mobility Design Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 7-4.

Gaps in Streetscape Filled with Trees



Source: T. Barker and A. Bell, *Mid-City Design Plan*, City of San Diego, Calif., 1984, p. 25.

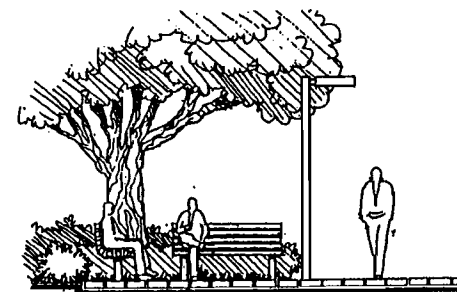
Functional Street Furniture

It is hard to draw a bead on the significance of street furniture. Critics of streetscape programs, including some of the most respected names in urban design, view the role of street furniture as largely cosmetic. Elegant streetlights and colorful banners cannot create a sense of place, says one designer. A sense of place requires a sense of space, well-defined public space, says a second.⁹⁷ Too much emphasis is placed on harmonizing street furniture when most street users will hardly notice, says a third.⁹⁸ In our own visual preference survey, the number of distinct types of street furniture visible in a scene proved insignificant (Appendix A).

Even granting its status as dessert rather than main course, street furniture may deserve more credit than it is given by these designers. The book *City Comforts* is filled with examples of how street furniture, cleverly designed and displayed, has added to the livability of that most livable city, Seattle.⁹⁹ Appropriately scaled and

positioned street lights can help define street space, and benches can add to the comfort level; an inordinate number of "great streets" are equipped with one or both.¹⁰⁰ Street furniture can help differentiate streets, giving them identity.¹⁰¹ In sum, street furniture can make at least modest contributions to many qualities of good urban design, including comfort and safety, human scale, complexity, coherence, and sense of place.

Shaded Benches Adding to the Comfort Level of Streets



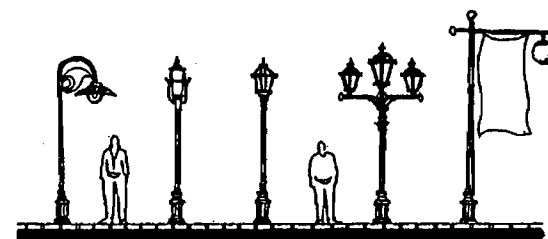
Source: Edward D. Stone, Jr. and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 3.21.

Street Lights Adding to the Complexity of Streets

NORTH SIDE

BEFORE

AFTER

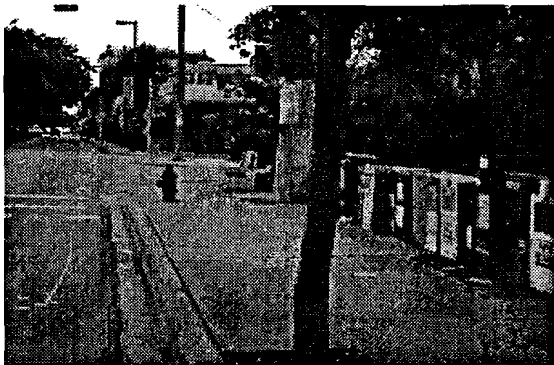


Source: Edward D. Stone, Jr. and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 3.40.

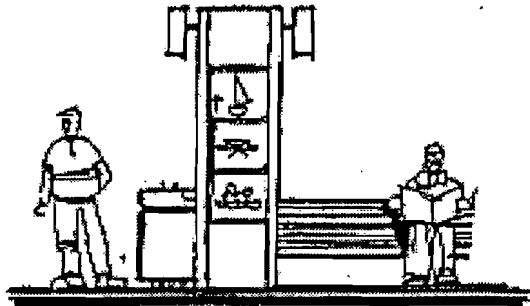
◆ II. Checklist of Pedestrian- and Transit Friendly Features ◆

Critics and admirers agree that street furniture can be overdone. Their advice: keep street furniture simple, use few materials and coherent colors, and don't be too cute.¹⁰² To avoid visual clutter and pedestrian obstruction, consolidate street furniture at intervals along the street, integrate street furniture with signage, and/or integrate street furniture into building facades.¹⁰³ Through consolidation and integration, locations with street furniture will take on special significance as pedestrian rest stops or primary transit stops.

Visual Clutter (Ft. Lauderdale)

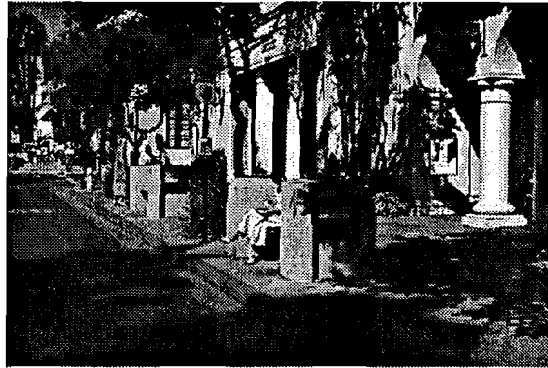


Signage Integrated with Street Furniture



Source: Edward D. Stone, Jr. and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 4-26.

*Integrated Designs that Include Transit
Santa Barbara*



Ft. Lauderdale



Miami



Coherent, Small-Scale Signage

In traditional cities, buildings dominate streetscapes due to their strong vertical lines and closeness to the street; landscaping and signage are secondary. In suburbs and suburb-like cities, including Florida's, roles are reversed. Buildings are so low, and are set back so far, that landscaping and signage become dominant image makers. The images created by suburban landscaping are generally positive, if a bit monotonous. The images created by signage are usually negative. "In their competition for the attention of the motoring public, merchants continually push the roadside visual envelope to its breaking point by erecting bigger, taller, and brighter signs."¹⁰⁴

Local governments have responded to the proliferation of garish highway signs by regulating the number, type, and size of signs. While avoiding the chaos of the commercial strip, the result of zealous sign regulation can be almost as bad. Signs can cease to convey information effectively or project distinctive character. They can become so standardized as to be tedious. Kevin Lynch and other top designers have recognized the creative possibilities afforded by good signage, artfully conceived rather than regulation-driven.¹⁰⁵

Signs Tailored to the Viewer and Use



Source: Edward D. Stone, Jr. and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 4.23.

In land development codes, sign size limits usually relate to lot frontage; the wider the lot, the bigger the sign may be and/or the more signs may be displayed. A more sensible basis for sizing signage is the design speed of the street along which signs are located. Along high-speed commuting routes, relatively large and simple signs are required to convey a message. Conversely, on streets that are meant to be walkable, design speeds are much lower and signs should be scaled down. Based upon extensive study of traveler reaction times, the seminal work, *Street Graphics*, offers guidelines for sign area and letter height as a function of land uses and travel speeds. For streets with design speeds of 15 mph, sign area should be limited to six to eight square feet and letter heights limited to four inches; such signs are also ideal for pedestrians.¹⁰⁶

Sign Specifications As a Function of Street Width, Design Speed, and Land Use

Street Width	Speed	Letter Height	Total Area of Sign*
Two Lanes	15 mph	4"	6-8 sq ft
	30	7	18-25
	45	10	36-50
Four Lanes	30	9	28-40
	45	13	64-90
	60	17	106-150
Six Lanes	30	9	28-40
	45	14	70-100
	60	19	134-190

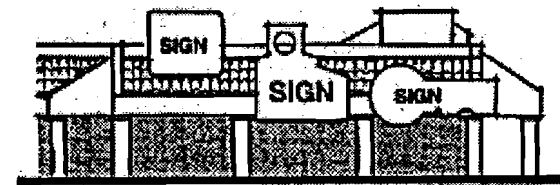
* The lower end of the size range applies to institutional and residential areas, the upper end to commercial and industrial areas.

Source: W.R. Ewald, *Street Graphics - A Concept and a System*, Landscape Architecture Foundation, McLean, VA, 1977, pp. 52-53.

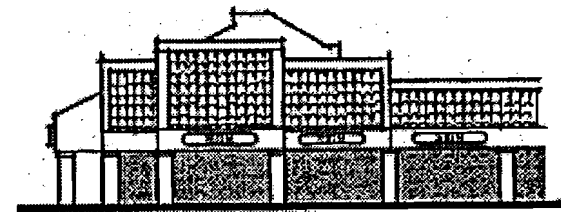
Beyond size, signs visible in a single scene must be coherent, that is, they must have a consistent vocabulary of shapes, materials, colors, and lettering. If signs have enough characteristics in common, the street scene will appear orderly. If not, it will appear messy. "High complexity urban areas must also be highly coherent."¹⁰⁷ The problem with a highway strip is not the surplus of information it imparts. Rather it is the complete absence of structure to the information; massive doses of unstructured information overwhelm. As

Chaotic vs. Coherent Sign Patterns

DON'T DO THIS



DO THIS



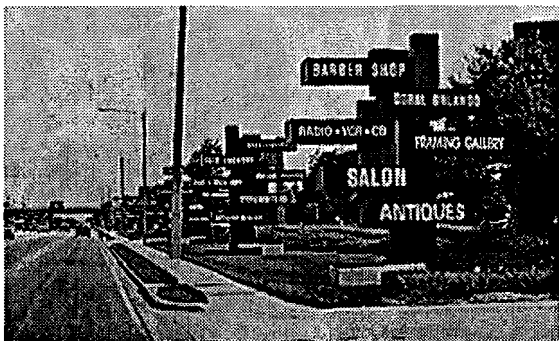
Source: City of San Bernardino, Calif., Title 19 - City of San Bernardino Municipal Code, 1991, p. II-133.

several visual preference studies have shown, including one study relating to street signage, scenes with moderate complexity and high coherence are the most favored of all.¹⁰⁸

*Complex and Coherent Signage
for Pedestrians
(Old Hyde Park Village, Tampa)*



*Complex and Coherent Signage
for Motorists
(Orlando)*



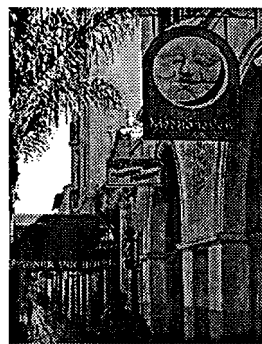
Finally, signs should convey a sense of “place,” in this case either the place of business they advertise or the larger district in which they are located.¹⁰⁹ The most memorable places in Florida have signage to match: South Beach in Miami, Sanibel Island, Key West, and other tourist meccas. Signs add to the fun and novelty of being there.

*Memorable Signage
in Memorable Places*

South Miami Beach



Santa Barbara, CA



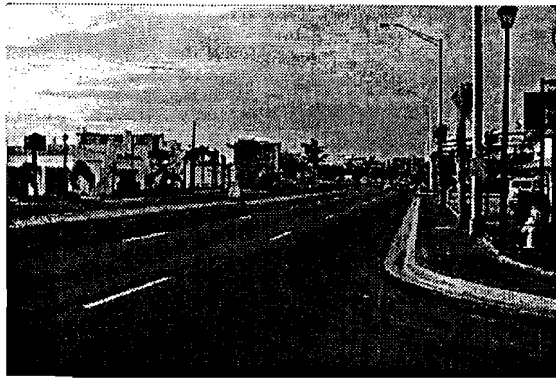
Special Pavement

With streets as outdoor rooms, the “walls” of the room are the buildings that bound and shape the street. The “ceiling” is the sky itself, which if bordering buildings are roughly the same height and close together, will be perceived as a ceiling through the power of suggestion. The “floor” is the street and sidewalk surface.

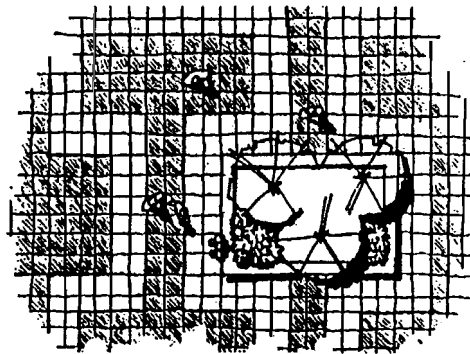
How important is the “floor”—its color, texture, and pattern—in making street space feel more room-like? On this the best minds disagree.¹¹⁰ Arguing for its importance are the fact that the street/sidewalk surface is touched as well as seen, that a pedestrian’s cone of vision is predominantly downward, that surfaces seem smaller if textured, and so on. Special paving can contribute something to at least four qualities of pedestrian-friendly design: human scale, linkage, complexity, and coherence.

Special paving’s contribution is necessarily limited, however, by the oblique angle at which pedestrians view pavement receding into the distance; any pattern quickly becomes indiscernible. Bricks, cobbles, pre-cast pavers, and patterned concrete cannot compensate for otherwise poorly defined street space. And they are relatively expensive as streetscape improvements go.¹¹¹ Elaborate pavement is as expensive as large, closely spaced trees and has much less visual impact.

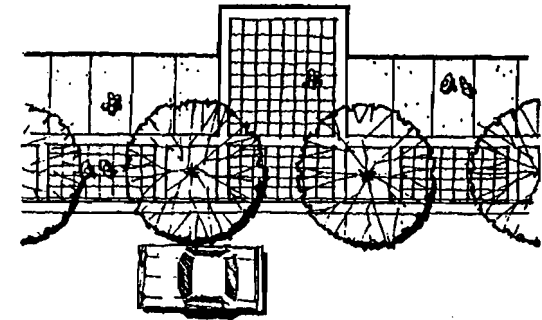
Poor Street Space Despite Streetscape Improvements (Miami)



Use of Special Paving to Break Up a Paved Expanse or Link a Building to the Street



Source: Edward D. Stone, Jr. and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 3.3.



Source: Edward D. Stone, Jr. and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 4.4.

Thus, special paving is probably best used as an accent rather than fill-in material, and used mainly where it serves some purpose other than a purely decorative one. Traffic calming is one such purpose. Used in a “gateway” entering a pedestrian zone, or a crosswalk within such a zone, textured pavement warns drivers to slow down and be on the lookout for pedestrians. For intensive traffic calming, a entire street section may be paved with brick, cobblestones, or pavers.

Use of Textured Surfaces as Warning Devices

Miami Lakes

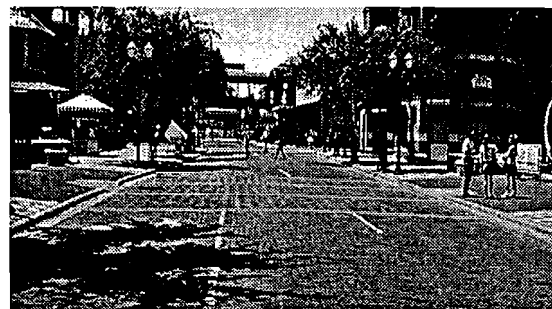


Santa Barbara, CA



Use of Textured Surfaces for Intensive Traffic Calming

Orlando



Jacksonville

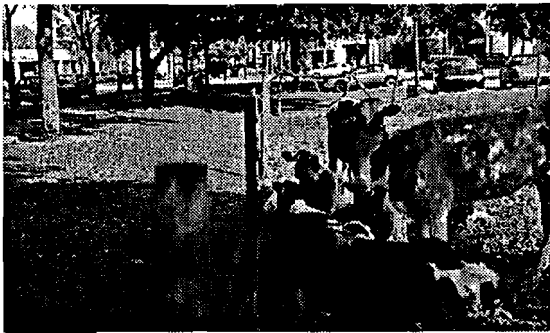


Also without costing a fortune, special paving may be used to visually break up large paved areas; provide linkage between buildings and streets, buildings and public spaces, or public spaces with one another; and to clearly delineate pedestrian, bicycle, and motor vehicle rights-of-way where boundaries are less than obvious.

Lovable Objects, Especially Public Art

Even spaces that are well-defined by buildings or other vertical elements can be characterless. That is, spaces can remain something less than places.¹¹² What are sometimes called “lovable objects” give meaning to places by making associations with the past, commemorating people and events, adding decorative richness, celebrating the natural environment, or introducing whimsy and humor.¹¹³

Lovable Objects—Believe It or Not—at a One-Time Dairy Farm (Miami Lakes)



Another Lovable Object—in the Same New Community (Miami Lakes)



Place Makers - Public Art That Tells You Where You Are profiles dozens of artworks that help define and enrich public places. The book defines public art broadly, as it should. Among the works profiled are sculpture, murals, decoratively shaped fountains, inlaid pavements, and mosaic-covered benches.¹¹⁴ There is anecdotal evidence that the introduction of public art—or more precisely, art in public places—can increase the level of pedestrian activity.¹¹⁵ Public art has this power

because it is not just artistic, like art in private collections. It is place-making.

If public art is sufficiently monumental, it can compensate for a fragmented frame of buildings. The art must have a vertical thrust to serve as a marker, and an open design to grasp and hold the space around it.¹¹⁶ This principal applies both to streets, whose end points can be marked with public art, and to parks and other public spaces, whose centers can be defined by public art.

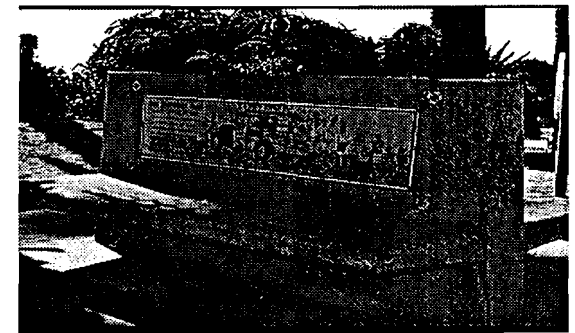
*Associations with the Past, Decorative Richness, and Whimsy
High Springs*



*Public Art Terminating a Street Vista and Centering a Village Green
Stuart*



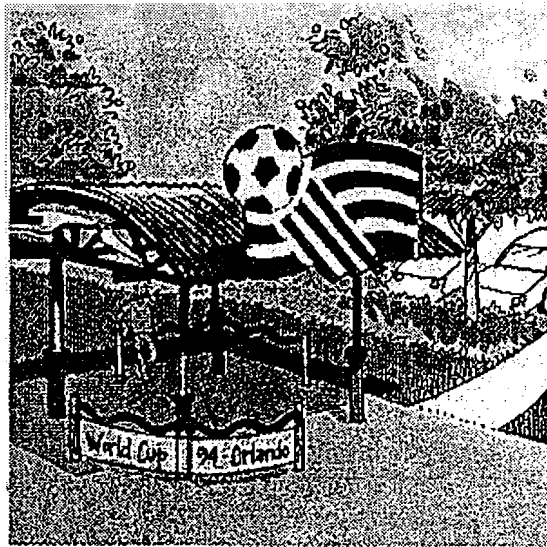
Santa Barbara, CA



Public art can humanize public spaces in a third, more subtle, way. In an impersonal world, public art represents a personal touch by the artist creating it and the institution erecting it.

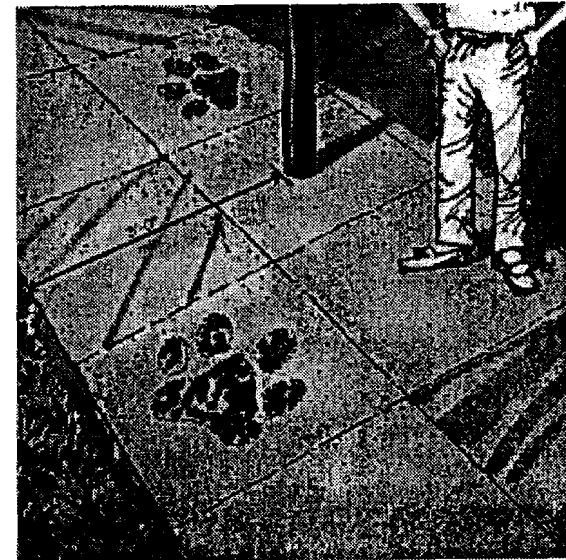
The transit operator in Orlando has plans to display public art at its superstops, transit stations, and park-and-ride lots. Public art may also be integrated into functional components such as shelters, benches, leaning rails, and light poles.

Public Art Integrated into a Bus Shelter



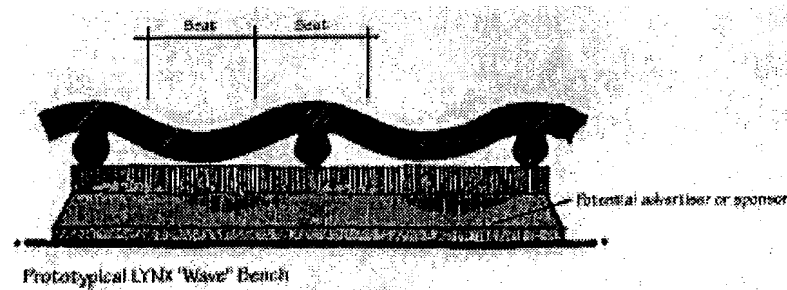
Source: Herbert - Halback, Inc., *Lynx - Customer Amenities Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 4.8.

Transit Logo Stamped Into the Pavement at a Primary Stop



Source: Herbert - Halback, Inc., *Lynx - Customer Amenities Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 5.3.

Visually "Fluid" Bus Bench



Source: Herbert - Halback, Inc., *Lynx - Customer Amenities Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 5.5.

ENDNOTES

¹ Some urban designers might object to this characterization as too limiting. Indeed, the best-known designers are famous for their work on urban form, community layout, and street network structure. Yet, when they address such issues, they have crossed over the line between design and planning to become leading practitioners in another field. The traditional concerns of urban design are clearly small-scale and aesthetic (where "aesthetic" is defined to include neighborhood identity, vibrant street life, etc.). See, for example, E.N. Bacon, *Design of Cities*, Viking Press, New York, 1974; R. Hedman, *Fundamentals of Urban Design*, American Planning Association, Chicago, IL, 1984; C. Alexander et al., *A New Theory of Urban Design*, Oxford University Press, New York, 1987; and K. Lynch, "Urban Design," In T. Banerjee and M. Southworth (eds.), *City Sense and City Design - Writing and Projects of Kevin Lynch*, MIT Press, Cambridge, MA, 1990, pp. 580-617.

² S.L. Handy, "Regional Versus Local Accessibility: Neo-Traditional Development and Its Implications for Non-Work Travel," Paper prepared for the 1992 Annual Meeting, American Collegiate Schools of Planning, 1992; R. Cervero, "Evidence on Travel Behavior in Transit-Supportive Residential Neighborhoods," *Transit-Supportive Development in the United States: Experiences and Prospects*, Technology Sharing Program, U.S. Department of Transportation, Washington, D.C., 1993, pp. 127-163; Parsons Brinckerhoff Quade Douglas, Inc., *The Pedestrian Environment*, 1000 Friends of Oregon, Portland, OR, 1993, pp. 29-34; Sasaki Associates, Inc., *Transit and Pedestrian Oriented Neighborhoods*, Maryland-National Capital Park & Planning Commission, Silver Spring, MD, 1993, pp. 47-53; Cambridge Systematics, Inc., *The Effects of Land Use and Travel Demand Management Strategies on Commuting Behavior*, Technology Sharing Program, U.S. Department of Transportation, Washington, D.C., 1994, pp. 3-19 through 3-21; B. Friedman, S.P. Gordon, and J.B. Peers, "Effect of Neotraditional Neighborhood Design on Travel Characteristics," *Transportation Research Record 1466*, 1994, pp. 63-70; and S.L. Handy, "Understanding The Link Between Urban Form and Travel Behavior," Paper presented at the 74th Annual Meeting, Washington, D.C., 1995.

³ R. Ewing, *Transportation and Land Use Innovations - When*

You Can't Build Your Way Out of Congestion, Florida Department of Community Affairs, Tallahassee, pending.

⁴ A. Duany and E. Plater-Zyberk, *Towns and Town-Making Principles*, Rizzoli International Publications, New York, 1991; L.W. Bookout, "Neotraditional Town Planning - A New Vision for the Suburbs?" *Urban Land*, Vol. 51, January 1992, pp. 20-26; A. Duany and E. Plater-Zyberk, "The Second Coming of the American Small Town," *Wilson Quarterly*, Vol. 16, 1992, pp. 19-48; A. Duany, E. Plater-Zyberk, and R. Shearer, "Zoning for Traditional Neighborhoods," *Land Development*, Vol. 5, Fall 1992, pp. 20-26; and P. Katz, "Seaside," *The New Urbanism - Toward an Architecture of Community*, McGraw-Hill, New York, 1994, pp. 2-17.

⁵ The designer is Peter Calthorpe, and he cites Mizner Park in his talks though not yet in his writings. P. Calthorpe, "Pedestrian Pockets: New Strategies for Suburban Growth," In D. Kelbaugh (ed.), *The Pedestrian Pocket Book - A New Suburban Design Strategy*, Princeton Architectural Press, New York, 1989, pp. 7-20; and P. Calthorpe, *The Next American Metropolis - Ecology, Community and the American Dream*, Princeton Architectural Press, New York, 1993. For more on the subject of urban and urbane centers in the suburbs, see P. Langdon, "Pumping Up Suburban Downtowns," *Planning*, Vol. 56, July 1990, pp. 22-28; J.H. Kay, "Building a There There," *Planning*, Vol. 57, January 1991, pp. 4-8; and J.R. Molinaro, "Creating a Vibrant Urban Core in the Suburbs," *Land Development*, Vol. 5, Winter 1993, pp. 16-20.

⁶ Hedman, op. cit., pp. 82-102; R.F. Galehouse, "Mixed-Use Centers in Suburban Office Parks," *Urban Land*, Vol. 43, August 1984, pp. 10-13; R.K. Untermann, "Adapting Suburban Communities," *Accommodating the Pedestrian - Adapting Towns and Neighborhoods for Walking and Bicycling*, Van Nostrand Reinhold Co., New York, 1984, pp. 173-229; R.E. Knack, "Zipping Up the Strip," *Planning*, Vol. 52, July 1986, pp. 22-27; T. Fisher, "Remaking Malls," *Progressive Architecture*, Vol. 69, November 1988, pp. 96-101; R. Hedman, "Suburban Sketchbook," *Planning*, Vol. 55, December 1989, pp. 16-17; K. Lynch and M. Southworth, "Designing and Managing the Strip," In T.

Banerjee and M. Southworth (eds.), *City Sense and City Design - Writing and Projects of Kevin Lynch*, MIT Press, Cambridge, MA, 1990, pp. 580-617; R.K. Untermann, "New Design Strategies for the Entire Road," *Linking Land Use and Transportation - Design Strategies to Serve HOVs and Pedestrians*, Washington State Department of Transportation, Seattle, 1991, Section 2; R.E. Knack, "Park and Shop: Some Guidelines," *Planning*, Vol. 58, May 1992, pp. 18-23; A. Achimore, "Putting the Community Back into Community Retail," *Urban Land*, Vol. 52, August 1993, pp. 33-38; S. DeSantis, T. Kirk, and D. Arambula, 1993 *Land Use, Transportation and Air Quality: A Manual for Planning Practitioners*, The Planning Center, Newport Beach, CA, 1993; Snohomish County Transportation Authority, *A Guide to Land Use and Public Transportation - Volume II: Applying the Concepts*, Lynnwood, WA, 1993, Chapters 3-5 ("Transit-Compatible Site Plans," "Transit-Friendly Shopping Centers," and "Redesign of a Strip Commercial Area"); D. Schwanke, T.J. Lassar, and M. Beyard, *Remaking the Shopping Center*, Urban Land Institute, Washington, D.C., 1994, pp. 31-89; I.F. Thomas, "Reinventing the Regional Mall," *Urban Land*, Vol. 53, February 1994, pp. 24-27; and T. Lassar, "Shopping Centers Can Be Good Neighbors," *Planning*, Vol. 61, October, 1995, pp. 14-19.

⁷ In the order subjects are listed, the seminal works are W.R. Ewald, *Street Graphics*, The Landscape Architecture Foundation, McLean, VA, 1977; R.L. Fleming and R. von Tschanner, *Place Makers - Public Art That Tells You Where You Are*, The Townscape Institute, Cambridge, MA, 1981; J. Gibbons and B. Oberholzer, *Urban Streetscapes - A Workbook for Designers*, Van Nostrand Reinhold, New York, 1992; and C.G. Miller, *Carscape - A Parking Handbook*, Washington Street Press, Columbus, IN, 1988.

⁸ R. Cervero, "Design Guidelines as a Tool to Promote Transit-Supportive Development," *Transit-Supportive Development in the United States: Experiences and Prospects*, Technology Sharing Program, U.S. Department of Transportation, Washington, D.C., 1993, pp. 27-40; and D. Everett, T. Herrero, and R. Ewing, *Transit-Oriented Development Guidelines - Review of Literature*, Background paper prepared for the Florida Department of Transportation, Tallahassee, 1995.

⁹ S.L. Kirmeyer, "Urban Density and Pathology," *Environment and Behavior*, Vol. 10, 1978, pp. 247-269; D.E. Schmidt, R.D. Goldman, and N.R. Feimer, "Perceptions of Crowding - Predicting at the Residence, Neighborhood, and City Levels," *Environment and Behavior*, Vol. 11, 1979, pp. 105-130; and E.E. Lozano, *Community Design and the Culture of Cities - The Crossroad and the Wall*, Cambridge University Press, New York, 1990, pp. 166-172.

¹⁰ P. Newman and T. Hogan, "A Review of Urban Density Models: Toward a Resolution of the Conflict Between Populace and Planner," *Human Ecology*, Vol. 9, 1981, pp. 269-303.

¹¹ T. Banerjee and P.G. Flachsbar, "Factors Influencing Perceptions of Residential Density," In V. Kouskoulas and R. Lyle (eds.), *Urban Housing and Transportation*, Wayne State University, Detroit, 1975; A. Rapoport, "Toward a Redefinition of Density," *Environment and Behavior*, Vol. 7, 1975, pp. 133-158; A. Rapoport, *Human Aspects of Urban Form: Toward a Man-Environment Approach to Urban Form and Design*, Pergamon Press, Oxford, England, 1977, pp. 201-207; P.G. Flachsbar, "Residential Site Planning and Perceived Densities," *Journal of Urban Planning and Development*, Vol. 105, 1979, pp. 103-117; E.R. Alexander and K.D. Reed, *Density Measures and Their Relation to Urban Form*, Center for Architecture and Urban Planning Research, University of Wisconsin-Milwaukee, 1988, pp. 3-8; and E.R. Alexander, "Density Measures: A Review and Analysis," *Journal of Architectural and Planning Research*, Vol. 10, 1993, pp. 181-202.

¹² H.S. Levinson and F.H. Wynn, "Effects of Density on Urban Transportation Requirements," *Highway Research Record* 2, 1963, pp. 38-64; A.M. Guest and C. Cluett, "Analysis of Transit Ridership Using 1970 Census Data," *Traffic Quarterly*, Vol. 30, 1976, pp. 143-161; K. Neels et al., *An Empirical Investigation of the Effects of Land Use on Urban Travel*, The Urban Institute, Washington, D.C., 1977, pp. 60-66; D.T. Hunt et al., "A Geodemographic Model for Bus Service Planning and Marketing," *Transportation Research Record* 1051, 1986, pp. 1-12; G. Harvey, *Relation of Residential Density to VMT Per Resident*, Metropolitan Transportation Commission, Oakland, CA, 1990; R.J. Spillar and G.S. Rutherford, "The Effects of Popula-

tion Density and Income on Per Capita Transit Ridership in Western American Cities," *ITE 1990 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1990, pp. 327-331; J. Holtzclaw, *Explaining Urban Density and Transit Impacts on Auto Use*, Sierra Club, San Francisco, 1991, pp. 18-24; P.W.G. Newman and J.R. Kenworthy, *Cities and Automobile Dependence: A Sourcebook*, Gower Technical, Brookfield, VT, 1991, pp. 34-68; R. Cervero, "Rail-Oriented Office Development in California: How Successful?" *Transportation Quarterly*, Vol. 48, 1994, pp. 33-44; R.T. Dunphy and K.M. Fisher, "Transportation, Congestion, and Density: New Insights," Paper presented at the 73rd Annual Meeting, Transportation Research Board, Washington, D.C., 1994; L.D. Frank and G. Pivo, "Impacts of Mixed Use and Density on the Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, and Walking," *Transportation Research Record* 1466, 1994a, pp. 44-52; L.D. Frank and G. Pivo, *Relationships Between Land Use and Travel Behavior in the Puget Sound Region*, Washington State Department of Transportation, Seattle, WA, 1994b, pp. 14-34; J. Holtzclaw, *Using Residential Patterns and Transit to Decrease Auto Dependence and Costs*, Natural Resources Defense Council, San Francisco, CA, 1994, pp. 20-21; and R. Kitamura, P.L. Mokhtarian, and L. Laidet, "A Micro-Analysis of Land Use and Travel in Five Neighborhoods in the San Francisco Bay Area," Paper presented at the 74th Annual Meeting, Transportation Research Board, Washington, D.C., 1994.

¹³ T. Schumacher, "Buildings and Streets: Notes on Configuration and Use," In S. Anderson (ed.), *On Streets*, MIT Press, Cambridge, MA, 1986, pp. 133-149.

¹⁴ C. Alexander, S. Ishikawa, and M. Silverstein, *A Pattern Language - Towns · Buildings · Construction*, Oxford University Press, New York, 1977, pp. 168-173 and 440-443.

¹⁵ Lozano, op. cit., pp. 131-144; J. Jacobs, *The Death and Life of Great American Cities*, Random House, New York, 1961, pp. 152-177; A. Jacobs and D. Appleyard, "Toward an Urban Design Manifesto," *Journal of the American Planning Association*, Vol. 53, 1987, pp. 112-120; W.H. Whyte, *City - Rediscovering the Center*, Doubleday, New York, 1988, pp. 89-90; A.B. Jacobs, *Great Streets*, MIT Press, Cambridge, MA, 1993, p. 304; D. Sucher, *City Comforts - How to Build and Urban Village*, City Comforts Press, Seattle, WA, 1995,

pp. 18-19; and G.R. Wekerle and C. Whitzman, *Safe Cities - Guidelines for Planning, Design, and Management*, Van Nostrand Reinhold, New York, 1995, pp. 44-49.

¹⁶ Cambridge Systematics, op. cit., pp. 3-5 through 3-10; Frank and Pivo, op. cit., 1994a; Frank and Pivo, op. cit., 1994b; Kitamura et al., op. cit.; A.R. Tomazinis et al., *A Study on Factors Affecting Success of Suburban Mass Transit Lines*, Urban Mass Transportation Administration, Washington, D.C., 1979, pp. 59-85; R. Cervero, "Land Use Mixing and Suburban Mobility," *Transportation Quarterly*, Vol. 42, 1988, pp. 429-446; R. Cervero, *America's Suburban Centers - The Land Use-Transportation Link*, Unwin Hyman, Boston, 1989, pp. 137-142; and R. Cervero, "Land Use and Travel at Suburban ActivityCenters," *Transportation Quarterly*, Vol. 45, 1991, pp. 479-491.

¹⁷ Studies relating home-based travel patterns to residential accessibility include: Handy, op. cit., 1992; Handy, op. cit., 1995; S. Hanson, "The Determinants of Daily Travel-Activity Patterns: Relative Location and Sociodemographic Factors," *Urban Geography*, Vol. 3, 1982, pp. 179-202; S. Hanson and M. Schwab, "Accessibility and Intraurban Travel," *Environment and Planning A*, Vol. 19, 1987, pp. 735-748; P.A. Williams, "A Recursive Model of Intraurban Trip-Making," *Environment and Planning A*, 1988, Vol. 20, pp. 535-546; P.A. Williams, "The Influence of Residential Accessibility on Household Trip-Making," *Socio-Economic Planning Sciences*, Vol. 23, 1989, pp. 373-385; S. Tarry, "Accessibility Factors at the Neighborhood Level," In *Environmental Issues*, PTRC Education and Research Services Ltd., London, England, 1992, pp. 257-270; S.L. Handy, "Regional Versus Local Accessibility: Implications for Nonwork Travel," *Transportation Research Record* 1400, 1993, pp. 58-66; R. Ewing, P. Haliyur, and G.W. Page, "Getting Around a Traditional City, a Suburban PUD, and Everything In-Between," *Transportation Research Record* 1466, 1994, pp. 53-62; and R. Ewing, "Beyond Density, Mode Choice, and Single-Purpose Trips," *Transportation Quarterly*, Vol. 49, 1995, pp. 15-24.

¹⁸ Ewing, op. cit., 1995; Ewing et al., op. cit.; Hanson, op. cit.; Hanson and Schwab, op. cit.; and Williams, op. cit.

¹⁹ Sucher, op. cit., p. 131.

²⁰ A. Jacobs, op. cit., pp. 260-262.

◇ II. Checklist of Pedestrian- and Transit Friendly Features ◇

²¹ Sucher, op. cit., p. 131; and R.K. Untermann, *Accommodating the Pedestrian - Adapting Towns and Neighborhoods for Walking and Bicycling*, Van Nostrand Reinhold, New York, 1984, p. 27.

²² J. Jacobs, op. cit., pp. 179-181.

²³ A. Jacobs, op. cit., p. 302; Sucher, op. cit., p. 131; and Whyte, op. cit., pp. 317-319.

²⁴ S.A. Smith et al., *Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas - Research Report*, National Cooperative Highway Research Program Report 294A, Transportation Research Board, Washington, D.C., 1987, p. 25; R.L. Knoblauch et al., *Investigation of Exposure Based Pedestrian Accident Areas: Crosswalks, Sidewalks, Local Streets and Major Arterials*, Federal Highway Administration, Washington, D.C., 1988, p. 54; and Post, Buckley, Schuh & Jernigan and J. Fruin, *Recommended Design Standards for the Florida Pedestrian Design Standards Development Study*, Florida Department of Transportation, Tallahassee, 1988, p. 32. The City of Toronto is contemplating an even stricter standard - a maximum block length of 150 meters (492 ft) before midblock pass-throughs are required. Planning and Development Department, *Urban Design Guidebook*, City of Toronto, October 1995 draft, p. 31.

²⁵ Travel distances were estimated assuming everyone walked at the NPTS average speed of 3.16 mph. Curves were smoothed to account for people's tendency to round off travel times.

²⁶ Snohomish County Transportation Authority, *A Guide to Land Use and Public Transportation*, Technology Sharing Program, U.S. Department of Transportation, Washington, D.C., 1989, p. 7-6; W. Bowes, M. Gravel, and G. Noxon, *Guide to Transit Considerations in the Subdivision Design and Approval Process*, Transportation Association of Canada, Ottawa, Ontario, 1991, p. A-8; Ontario Ministry of Transportation, *Transit-Supportive Land Use Planning Guidelines*, Toronto, 1992, pp. 45-46; and Denver Regional Council of Governments, *Suburban Mobility Design Manual*, Denver, CO, 1993, p. 26.

²⁷ For a more complete discussion, see R. Ewing, *Best De-*

velopment Practices - Doing the Right Thing and Making Money at the Same Time, American Planning Association, Chicago, IL, 1996, in press.

²⁸ R.K. Untermann, "Street Design - Reassessing the Function, Safety and Comfort of Streets for Pedestrians," In *The Road Less Traveled: Getting There by Other Means*, 11th International Pedestrian Conference, City of Boulder, CO, 1990, pp. 19-26.

²⁹ For a review of literature and the most comprehensive evaluation of median safety impacts to date, see B.L. Bowman and R.L. Vecellio, "An Assessment of Current Practice in the Selection and Design of Urban Medians to Benefit Pedestrians," Paper presented at the 73rd Annual Meeting, Transportation Research Board, Washington, D.C., 1994; and B.L. Bowman and R.L. Vecellio, "The Effect of Urban/Suburban Median Types on Both Vehicular and Pedestrian Safety," Paper presented at the 73rd Annual Meeting, Transportation Research Board, Washington, D.C., 1994.

³⁰ Smith et al., op. cit., pp. 61-62.

³¹ W. Kulash, "Neotraditional Town Design -- Will the Traffic Work?" Session Notes - AICP Workshop on Neotraditional Town Planning, American Institute of Certified Planners, Washington, D.C., 1991.

³² J. Jacobs, op. cit., pp. 29-88.

³³ Florida Department of Transportation (FDOT), *Florida Pedestrian Safety Plan*, Tallahassee, 1992, pp. II-3 and II-4.

³⁴ J.H. Allen, "Engineering Pedestrian Facilities," In *Getting There by All Means: Interrelationships of Transportation Modes*, 8th International Pedestrian Conference, City of Boulder, CO, 1987, pp. 213-222.

³⁵ J.J. Fruin, *Pedestrian Planning and Design*, Metropolitan Association of Urban Designers and Environmental Planners, Inc., New York, 1971, pp. 42 and 47-50.

³⁶ Alexander et al., op. cit., 1977, pp. 170-171 and 596-598; A. Jacobs, op. cit., p. 273; and B. Pushkarev and J.M. Zupan, *Urban Space for Pedestrians*, MIT Press, Cambridge, MA, 1975, pp. 127-129.

³⁷ Pushkarev and Zupan, op. cit., pp. 151-152.

³⁸ Fruin, op. cit., p. 44.

³⁹ National Safety Council, *Accident Facts*, Chicago, IL, 1993, pp. 55, 69.

⁴⁰ Knoblauch et al., op. cit., pp. 9-16; R.N. Schwab et al., "Roadway Lighting," In *Synthesis of Safety Research Related to Traffic Control and Roadway Elements - Volume 2*, Federal Highway Administration, Washington, D.C., 1982, pp. 12-1 through 12-17; and C.V. Zegeer, *Synthesis of Safety Research - Pedestrians*, Federal Highway Administration, Washington, D.C., 1991, pp. 38-50.

⁴¹ Untermann, op. cit., 1990.

⁴² W.G. Berger, *Urban Pedestrian Accident Countermeasures Experimental Evaluation - Volume 1 - Behavioral Evaluation Studies*, National Highway Safety Administration and Federal Highway Administration, Washington, D.C., 1975, pp. 3-25 through 3-32.

⁴³ National Safety Council, op. cit., p. 69; and N.J. Garber and R. Srinivasan, *Accident Characteristics of Elderly Pedestrians*, Mid-Atlantic Universities Transportation Center, University Park, PA, 1990, pp. 17-18.

⁴⁴ This crosswalk guideline is endorsed by both the Federal Highway Administration and the Florida Department of Transportation. See Knoblauch et al., op. cit., p. 54; and Post, Buckley, Schuh & Jernigan and Fruin, op. cit., p. 32.

⁴⁵ Pedestrian signals do little for pedestrians where vehicle turning movements are allowed at the same time across the paths of pedestrians. However, where protected pedestrian crossings are provided via exclusive signals (traffic is held on all approaches while pedestrians cross), accident rates are significantly lower. C.V. Zegeer, K.S. Opiela, and M.J. Cynecki, "Effect of Pedestrian Signals and Signal Timing on Pedestrian Accidents," *Transportation Research Record* 847, 1982, pp. 62-72; and C.V. Zegeer, K.S. Opiela, and M.J. Cynecki, *Pedestrian Signalization Alternatives - Final Report*, Turner-Fairbank Highway Research Center,

McLean, VA, 1985, pp. 33-43.

⁴⁶ Untermann, op. cit., 1984, pp. 103 and 180-181.

⁴⁷ See discussion in American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1990, pp. 706-712.

⁴⁸ Smith et al., op. cit., p. 35; and R. Ewing, *Developing Successful New Communities*, Urban Land Institute, Washington, D.C., 1991, pp. 78-79.

⁴⁹ R.E. Knack, "Pedestrian Malls: Twenty Years Later," *Planning*, Vol. 48, December 1982, pp. 15-20; K.A. Robertson, "The Status of the Pedestrian Mall in American Downtowns," *Urban Affairs Quarterly*, Vol. 26, 1990, pp. 250-273; and L.O. Houstoun, "From Street to Mall and Back Again," *Planning*, Vol. 56, June 1990, pp. 4-10.

⁵⁰ A. Jacobs, "City Streets and Their Contexts," In *A Decade Reviewed - Commitment Renewed*, 10th Annual Pedestrian Conference, City of Boulder, CO, 1989, pp. 41-61.

⁵¹ Alexander et al., op. cit., 1977, p. 287.

⁵² For safety reasons, curbside parking is not favored in residential areas; it is a prime contributor to pedestrian accidents (including dart-out accidents involving children). See the literature review in D.E. Cleveland, M.J. Huber, and M.J. Rosenbaum, "On-Street Parking," In *Synthesis of Safety Research Related to Traffic Control and Roadway Elements - Volume I*, Federal Highway Administration, Washington, D.C., 1982, pp. 9-1 through 9-16. Also see Henning-Hager, op. cit.; J.B. Humphreys et al., *Safety Aspects of Curb Parking - Final Technical Report*, Federal Highway Administration, Washington, D.C., 1978, pp. 33-121; and G. Sokolow, "Should the Transportation Profession Encourage On-Street Parking in Our Neighborhoods?" Unpublished paper available from the author, Florida Department of Transportation, Tallahassee, FL, 1991. In residential areas, on-street parking is seen as more of a threat than a protection from traffic. D. Appleyard, *Livable Streets*, University of California Press, Berkeley, 1981, p. 141.

⁵³ Christopher Alexander advocates curbs 18 inches high, 58

not seen much nowadays but common historically. Pedestrians begin to feel secure when they are 18 inches above the street. Alexander attributes this to the symbolic superiority of pedestrians when their eye level is above the roofs of cars; and to the constant, unspoken threat eliminated when the curb is high enough to prevent a runaway car from easily mounting it. Alexander et al., op. cit., 1977, pp. 285-288.

⁵⁴ A marvelously lucid history of residential development is provided in M. Southworth and P.M. Owens, "The Evolving Metropolis - Studies of Community, Neighborhood, and Street Form at the Urban Edge," *Journal of the American Planning Association*, Vol. 59, 1993, pp. 271-287.

⁵⁵ O. Newman, *Community of Interest*, Anchor Press/Doubleday, Garden City, NY, 1980, p. 171.

⁵⁶ D.T. Smith and D. Appleyard, *Improving the Residential Street Environment*, Federal Highway Administration, Washington, D.C., 1981, pp. 123-130.

⁵⁷ J. Jacobs, op. cit., p. 35.

⁵⁸ A. Jacobs, op. cit., 1993, pp. 285-287.

⁵⁹ For successful examples, see Fisher, op. cit.; Lassar, op. cit.; Schwanke et al., op. cit., pp. 31-59; and Thomas, op. cit.

⁶⁰ Wekerle and Whitzman, op. cit., pp. 61-150; O. Newman, *Defensible Space - Crime Prevention Through Urban Design*, Collier Books, New York, 1972, pp. 71-79; B. Poyner, *Design Against Crime - Beyond Defensible Space*, Butterworths, New York, 1983, pp. 15-27; T.D. Crowe, *Crime Prevention Through Environmental Design - Applications of Architectural Design and Space Management Concepts*, Butterworth-Heinemann, Boston, MA, 1991, p. 161; P. Stollard, *Crime Prevention Through Housing Design*, E & F N Spon, London, 1991, pp. 21-26; and O. Newman, "Defensible Space - A New Physical Planning Tool for Urban Revitalization," *Journal of the American Planning Association*, Vol. 61, 1995, pp. 149-155.

⁶¹ Florida Department of Transportation (FDOT), op. cit., 1994, p. III-81.

⁶² R.L. Fleming, *Saving Face - How Corporate Franchise*

Design Can Respect Community Identity, Planning Advisory Service Report Number 452, American Planning Association, Chicago, IL, 1994.

⁶³ C.E. Beaumont, *How Superstore Sprawl Can Harm Communities - And What Communities Can Do About It*, National Trust for Historic Preservation, Washington, D.C., 1994, pp. 89-100. Also see S. Lewis, "When Wal-Mart Says 'Uncle'," *Planning*, Vol. 60, August 1994, pp. 14-19.

⁶⁴ Probably the most spirited recent defense of the grid (or critique of the curvilinear alternative) can be found in Kulash, op. cit. For a history of the street grid -- its rise, fall, and apparent rise again -- see C.R. Wolfe, "Streets Regulating Neighborhood Form: A Selective History," In A. Vernez Moudon (ed.), *Public Streets for Public Use*, Columbia University Press, New York, 1991, pp. 110-122.

⁶⁵ C. Tunnard and B. Pushkarev, *Man-Made America - Chaos or Control? An Inquiry into Selected Problems of Design in the Urbanized Landscape*, Yale University Press, New Haven, CT, 1963, p. 98. Even before Tunnard and Pushkarev, Kevin Lynch spoke of modifications to the rectangular grid that would overcome its visual monotony, disregard for topography, vulnerability to through-traffic, and lack of differentiation between heavily traveled and lightly traveled ways. K. Lynch, *Site Planning*, MIT Press, Cambridge, MA, 1962, pp. 40-41.

⁶⁶ Appleyard, op. cit., pp. 41-78; and Smith and Appleyard, pp. 113-130.

⁶⁷ Smith and Appleyard, op. cit., pp. 59-97; O.T. Farouki and W.J. Nixon, "The Effect of Width of Suburban Roads on the Mean Free Speed of Cars," *Traffic Engineering and Control*, Vol. 17, 1976, pp. 518-519; W. Marconi, "Speed Control Measures in Residential Areas," *Traffic Engineering*, Vol. 47, March 1977, pp. 28-30; R. Sumner and C. Baguley, *Speed Control Humps on Residential Roads*, Transport and Road Research Lab, Crowthorne, England, 1979, pp. 3-10; M.R. Daff and I.D.K. Siggins, "On Road Trials of Some New Types of Slow Points," Vol. 11, 1982, pp. 214-237; J.P. Clement, "Speed Humps and the Thousand Oaks Experience," *ITE Journal*, Vol. 53, January 1983, pp. 35-39; C.L. Heimbach, P.D. Cribbins, and M.S. Chang, "Some Partial Consequences of Reduced Traffic Lane Widths on

Urban Arterials," *Transportation Research Record* 923, 1983, pp. 69-72; M. Fager, "Environmental Traffic Management in Stockholm," *ITE Journal*, Vol. 54, July 1984, pp. 16-19; H.S. Lum, "The Use of Road Markings to Narrow Lanes for Controlling Speed in Residential Areas," *ITE Journal*, Vol. 54, June 1984, pp. 50-53; J.E. Clark, "High Speeds and Volumes on Residential Streets: An Analysis of Physical Street Characteristics as Causes in Sacramento, California," *ITE 1985 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1985, pp. 93-96; B.D. Kanely, "Traffic Diverters for Residential Traffic Control—The Gainesville Experience," *ITE 1985 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1985, pp. 72-76; D. Meier, "The Policy Adopted in Arlington County, Virginia, for Solving Real and Perceived Speeding Problems on Residential Streets," *ITE 1985 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1985, pp. 97-101; E.W. von Borstel, "Traffic Circles: Seattle's Experience," *ITE 1985 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1985, pp. 77-81; J.J. Nitzel, F.G. Schattner, and J.P. Mick, "Residential Traffic Control Policies and Measures," *ITE 1988 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1988, pp. 217-223; W.S. Homburger et al., *Residential Street Design and Traffic Control*, Prentice Hall, Englewood Cliffs, NJ, 1989, pp. 79-112; D.A. Nicodemus, "Safe and Effective Roadway Humps - The Seminole County Profile," *ITE 1991 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1991, pp. 102-105; R.C. Welke, "Guidelines for the Establishment and Maintenance of Realistic Speed Limits on Public Roadways in Montgomery County, Maryland," *ITE 1991 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1991, pp. 89-96; S.D. Challis, "North Earlham Estate, Norwich - The First UK 20 mph Zone," In *Traffic Management and Road Safety*, PTRC Education and Research Services Ltd., London, England, 1992, pp. 61-72; M. Durkin and T. Pheby, "York: Aiming To Be the UK's First Traffic Calmed City," In *Traffic Management and Road Safety*, PTRC Education and Research Services Ltd., London, England, 1992, pp. 73-90; H. Stein et al., "Portland's Successful Experience with Traffic Circles," *ITE 1992 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1992, pp. 39-44; D. Zaidel, A.S.

Hakkert, and A.H. Pistiner, "The Use of Road Humps for Moderating Speeds on Urban Streets," *Accident Analysis and Prevention*, Vol. 24, 1992, pp. 45-56; and M. Klik and A. Faghri, "A Comparative Evaluation of Speed Humps and Deviations," *Transportation Quarterly*, Vol. 47, 1993, pp. 457-469; A. Clarke and M.J. Dornfeld, *Traffic Calming, Auto-Restricted Zones and Other Traffic Management Techniques - Their Effects on Bicycling and Pedestrians*, Case Study No. 19, National Bicycling and Walking Study, Federal Highway Administration, Washington, D.C., 1994, pp. 27-39; C.E. Walter, "Suburban Residential Traffic Calming," *ITE Journal*, Vol. 65, 1995, pp. 44-48; and C.L. Hoyle, *Traffic Calming*, Planning Advisory Service Report Number 456, American Planning Association, Chicago, 1995, pp. 10-15.

⁶⁸ Their approaches to traffic calming are reviewed in R. Tolley, *Calming Traffic in Residential Areas*, Brefi Press, Brefi, England, 1990. Also see TEST, *Quality Streets - How Traditional Urban Centres Benefit from Traffic-Calming*, London, 1988; CART, *Traffic Calming*, Sensible Transportation Options for People, Tigard, OR, 1989; H.H. Keller, "Three Generations of Traffic Calming in the Federal Republic of Germany," *Environmental Issues*, PTRC Education and Research Services, Sussex, England, 1989, pp. 15-31; S.T. Janssen, "Road Safety in Urban Districts - Final Results of Accident Studies in the Dutch Demonstration Projects of the 1970s," *Traffic Engineering + Control*, Vol. 32, 1991, pp. 292-296; R. Brindle, "Local Street Speed Management in Australia - Is It 'Traffic Calming'?" *Accident Analysis and Prevention*, Vol. 24, 1992, pp. 29-38; J. Pucher and S. Clorer, "Taming the Automobile in Germany," *Transportation Quarterly*, Vol. 46, 1992, pp. 383-395; L. Herrstedt et al., *An Improved Traffic Environment - A Catalogue of Ideas*, Danish Road Directorate, Copenhagen, Denmark, 1993; W. Brilon and H. Blanke, "Extensive Traffic Calming: Results of the Accident Analyses in Six Model Towns," *ITE 1993 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1993, pp. 119-123; J. Craus et al., "Geometric Aspects of Traffic Calming in Shared Streets," *ITE 1993 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1993, pp. 1-5; A. O'Brien, "Traffic Calming - Ideas Into Practice," *ITE 1993 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1993, pp. 129-134; and R. Ewing, "Residential Street Design: Do the British and

Australians Know Something We Americans Don't?" *Transportation Research Record* 1455, 1994, pp. 42-49.

⁶⁹ Sucher, op. cit., p. 127. Also see Clarke and Dornfeld, op. cit.; Homburger et al., op. cit.; Hoyle, op. cit.; S. Grava, "Traffic Calming - Can It Be Done in America?" *Transportation Quarterly*, Vol. 47, 1993, pp. 483-505; R. Drdul and M. Skene, "Traffic Calming Do's and Don'ts," *ITE 1994 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1994, pp. 491-495; and K. Halperin and R. Huston, "A Verkehrsberuhigung Design for an American Road," *ITE Journal*, Vol. 64, April 1994, pp. 28-34.

⁷⁰ A bioclimatic chart relates human comfort to four major climate variables -- temperature, relative humidity, sunlight, and wind. For an introduction to this subject, see G.Z. Brown, *Sun, Wind, and Light - Architectural Design Strategies*, John Wiley & Sons, New York, 1985, pp. 33-35 and 50-51.

⁷¹ H.F. Arnold, *Trees in Urban Design*, Van Nostrand Reinhold, New York, 1993, pp. 173-181.

⁷² Arnold, op. cit., p. 56.

⁷³ Arnold, op. cit., pp. 2-11.

⁷⁴ Whyte, op. cit., pp. 314-315.

⁷⁵ Alexander et al., op. cit., pp. 120-125.

⁷⁶ J.B. Kenyon, "A Model of Downtown Pedestrian Generation," In *Getting There by All Means: Interrelationships of Transportation Modes*, 8th International Pedestrian Conference, City of Boulder, CO, 1987, pp. 233-237.

⁷⁷ A. Jacobs, op. cit., 1993, pp. 305-306.

⁷⁸ Barton-Aschman Associates, Inc., *Shared Parking*, Urban Land Institute, Washington, D.C., 1983; T.P. Smith, *Flexible Parking Requirements*, Planning Advisory Service Report Number 377, American Planning Association, Chicago, IL, 1983; S.J. TenHoor and S.A. Smith, *Model Parking Code Provisions to Encourage Ridesharing and Transit Use*, Federal Highway Administration, Washington, D.C., 1983; S.J. TenHoor and S.A. Smith, *Model Parking Code*

Provisions to Encourage Ridesharing and Transit Use (including a Review of Experience), Federal Highway Administration, Washington, D.C., 1983; T.P. Smith, *The Aesthetics of Parking*, Planning Advisory Service Report Number 411, American Planning Association, Chicago, 1988; and J.B. Goldsteen, "Parking Standards and Requirements: Update, Summary, and Literature Review," *Strategies to Alleviate Traffic Congestion*, Institute of Transportation Engineers, Washington, D.C., 1993, pp. 158-192.

⁷⁹ Calthorpe, op. cit., p. 110.

⁸⁰ Bacon, op. cit., p. 18; Hedman, op. cit., 1984, p. 1-7 and 57-70; and A. Jacobs, op. cit., 1993, pp. 282-284.

⁸¹ Whyte, op. cit., pp. 222.

⁸² Whyte, op. cit., p. 227.

⁸³ For those doubting the truth of this statement, consider the clear preference of children for play in and around streets, over play in nearby playgrounds. Or the crowding in shops along South Beach in Miami or Park Avenue in Winter Park, while parks across the street remain only lightly used most of the time. It is no coincidence that all the great public places cited by Ray Oldenburg -- places that host the regular, informal gatherings of individuals -- are commercial establishments. R. Oldenburg, *The Great Good Place*, Paragon House, New York, 1989.

⁸⁴ A. Jacobs, op. cit., 1993, pp. 301 and 306-307. There is nothing special about most streets in urban areas, nothing that differentiates one from another. This has been a cause of concern for designers, for it makes the street network less legible to travelers and undermines any sense of place. See Hedman, op. cit., 1984, pp. 89-93; and W.C. Ellis, "The Spatial Structure of Streets," In S. Anderson (ed.), *On Streets*, MIT Press, Cambridge, MA, 1986, pp. 115-131.

⁸⁵ Whyte, op. cit., p. 129.

⁸⁶ J. Jacobs, op. cit., pp. 89-111.

⁸⁷ Ewing, op. cit., in press.

⁸⁸ Alexander et al., op. cit., pp. 114-119; and H. Blumenfeld, *The Modern Metropolis: Its Origins, Growth,*
60

Characteristics, and Planning, MIT Press, Cambridge, MA, 1967, pp. 217-218.

⁸⁹ In one survey, 57% of residents preferred the ground floor to the fourth floor of an apartment building; only 13% preferred the ninth floor and above. Y. Yeung, "High-rise, High-density Housing: Myths and Reality," *Habitat International*, Vol. 2, 1977, pp. 587-594.

⁹⁰ A. Jacobs, op. cit., 1993, p. 281.

⁹¹ Jacobs and Appleyard, op. cit.

⁹² Hedman, op. cit., 1984, pp. 20-21, 44-51, 60-70, and 105-135.

⁹³ R. Trancik, *Finding Lost Space - Theories of Urban Design*, Van Nostrand Reinhold, New York, 1986, p. 39.

⁹⁴ L. Cappe, "Including Transit," In A.V. Moudon (ed.), *Public Streets for Public Use*, Columbia University Press, New York, 1991, pp. 290-298.

⁹⁵ Herbert Halback, Inc., *Customer Amenities Manual*, LYNX - Central Florida Regional Transportation Authority, Orlando, 1994, p. 2.1.

⁹⁶ See, for example, Duany and Plater-Zyberk, op. cit., 1992; Ellis, op. cit.; and E. Moule and S. Polyzoides, "The Street, the Block, and the Building," In *The New Urbanism - Toward an Architecture of Community*, McGraw-Hill, New York, 1994, pp. xxi-xxiv.

⁹⁷ Duany and Plater-Zyberk, op. cit., 1992.

⁹⁸ Lynch and Hack, op. cit., p. 187.

⁹⁹ Sucher, op. cit.

¹⁰⁰ A. Jacobs, op. cit., 1993, pp. 299-301.

¹⁰¹ Hedman, op. cit., 1984, pp. 92-93.

¹⁰² Gibbons and Oberholzer, op. cit., pp. 3-4; Hedman, op. cit., 1984, pp. 95-97; and Whyte, op. cit., p. 102.

¹⁰³ Gibbons and Oberholzer, op. cit., p. 4.

¹⁰⁴ K.R. Bishop, *Designing Urban Corridors*, Planning Advisory Service Report Number 418, American Planning Association, Chicago, 1989, p. 7.

¹⁰⁵ Lynch and Hack, op. cit., pp. 187-188.

¹⁰⁶ Ewald, op. cit., pp. 52-53.

¹⁰⁷ TR. Herzog, S. Kaplan, and R. Kaplan, "The Prediction of Preference for Unfamiliar Urban Places," *Population and Environment*, Vol. 5, 1982, pp. 43-59. Also see J.L. Nasar, "The Evaluative Image of the City," *Journal of the American Planning Association*, Vol. 56, 1990, pp. 41-53.

¹⁰⁸ J.L. Nasar, "The Effect of Sign Complexity and Coherence on the Perceived Quality of Retail Scenes," *Journal of the American Planning Association*, Vol. 53, 1987, pp. 499-509.

¹⁰⁹ Ewald, op. cit., pp. 38-40.

¹¹⁰ Among the designers perceiving special pavement as important are Lynch and Hack, op. cit., p. 170; Trancik, op. cit., p. 61; and Untermann, op. cit., 1984, p. 59. Minimizing its importance are Arnold, op. cit., p. 10; Hedman, op. cit., 1984, p. 82; and A. Jacobs, op. cit., 1993, p. 300.

¹¹¹ D. Nichols, "Paving," In *Handbook of Landscape Architectural Construction - Volume IV - Materials for Landscape Construction*, Landscape Architecture Foundation, Washington, D.C., 1992, pp. 69-138.

¹¹² Trancik, op. cit., pp. 112-124.

¹¹³ Fleming and von Tschärner, op. cit., pp. 7-15.

¹¹⁴ Fleming and von Tschärner, op. cit., pp. 20-109.

¹¹⁵ Whyte, op. cit., pp. 144-148.

¹¹⁶ Hedman, op. cit., 1984, pp. 85-87; and J.B. Goldsteen and C.D. Elliott, *Designing America: Creating Urban Identity*, Van Nostrand Reinhold, New York, 1994, pp. 171-172.

Appendix A

Visual Preference Survey - Bus Stop Features

In dealing with the aesthetic or visual qualities of design, designers tend to impose their own taste instead of user (client) preferences or, at best, tend to make naive assumptions about user preferences.¹

Most transit-oriented design (TOD) manuals contain guidelines related to site planning, pedestrian access, road geometrics, and bus stop siting and design. The stated purpose is to make developers, public officials, and highway agencies more sensitive to transit needs. Yet of the TOD manuals reviewed, not one appears to have asked transit users or potential users about their needs and wants. Instead, newer manuals borrow from older ones and all rely heavily on assumptions (whether naive or not) about user preferences.

This manual is an exception, being based in part on a visual preference survey of transit users, nonusers, and for the sake of comparison, transit professionals. This may be the first-ever application of visual preference survey methods to transit facilities.

What follows is a brief introduction to visual preference surveys; a description of our survey and results; and a discussion of implications for transit-oriented design.

Visual Preference Surveys Generally

Visual preference surveys help citizens and community leaders envision design alternatives in ways that words, maps, and other communications media cannot. This makes them ideal for "visioning" projects, design charrettes, and other physical planning activities with public involvement.

Visual preference surveys have received national attention recently in the campaign to redesign suburban America. Surveys by "neo-traditional planners" and "new urbanists" have shown that the public, by a wide margin, prefers traditional small town and village scenes to contemporary suburban scenes. This fact has been used to argue for, and effect, changes in land development codes and development practices.³

Long before neo-traditional planners embraced them, visual preference surveys were being used as research tools by forest managers, environmental psychologists, and landscape architects. Survey methods were first applied to wildlands, later to urban parks and urban landscapes, and still later to specific urban design elements such as signage and parking.⁴

From decades of experience, the parameters within which visual preference studies must operate are well-defined. They guided the conduct of this study.

- Visual preference surveys usually have 50 to 100 subjects evaluating scenes, sometimes more when the subjects are students and participation in the survey is a course requirement (as it is in so many published studies). However, smaller groups are sometimes used for specialized surveys such as ours, and groups as small as 15 viewers, each evaluating dozens of scenes, are reliable enough for most applications.⁵ *Participating in our survey were 20 transit users, 13 nonusers, and seven transit professionals (mostly administrative staff); our results must be discounted somewhat for nonusers and professionals, given the number of subjects involved.*

- Viewers are usually shown photographs of scenes, though line drawings or computer-generated graphics have been used occasionally. The photographs may be either slides or enlarged prints. They may be either in black-and-white or color. Viewers' reactions to photographs are similar to reactions to same scenes in the field (though, in this respect, slides may have a slight advantage over enlarged prints and color has an advantage over black-and-white).⁶ *We*

used color slides both for realism and economy of presentation.

- When slides are used, viewing time may vary from a fraction of a second to a half a minute. Viewers' reactions may be heightened by extended viewing time but do not appear to change with extended viewing time (if initially positive, they remain positive...).⁷ *We allowed 30 seconds for three tasks: the choice between paired bus stops, the rating of the chosen stop, and a brief written explanation for the choice.*

- By far the most common way to assess preferences is with rating/scaling methods; scenes are displayed individually in random order and assigned ratings on a Likert scale. The most common scale is 1 to 5 (1 being least preferred, 5 most preferred), but many variations—1 to 7, 1 to 10, -10 to +10, etc.—are found in the literature. *In our rating exercise, a simple 1 to 5 scale was used on the theory that viewers would have trouble distinguishing among finer gradations.*

- The simplest method of analysis is to average the ratings given to scenes of different types. This also is the method of analysis that provides the least useful information. Many neo-traditional surveys are analyzed in this manner. Without further analysis, it is never clear whether differences in average ratings are significant nor which features of scenes are responsible for high or low ratings.⁸ More sophisticated visual preference studies use analysis of variance to test for significant differences among scenes and/or use multiple re-

gression analysis to explain differences in terms of slide content.⁹ *Multiple regression analysis enabled us to relate bus stop ratings to features of the stops and their surroundings.*

- Two alternatives to rating/scaling are available for assessing visual preferences; they are ordinal ranking of scenes and forced choice between scenes in paired comparisons. Ranking is used in other fields but not much in visual preference surveys, doubtless because the common medium (slides) precludes side-by-side comparisons of more than a few scenes. Likewise, paired comparisons are used in other fields but seldom in visual preference surveys; in this case, though, no good reason comes to mind. Indeed, in the parallel field of *stated preference* research, paired comparisons are more common and considered more reliable than rating/scaling methods.¹⁰ *We used both paired comparisons and ratings, but our study design emphasized the paired comparisons.*

This Survey and Analysis

Survey participants were recruited by the Sarasota County Transportation Authority, Sarasota's local bus operator. Free transit passes were offered as an inducement to participate, and refreshments were provided as well. Two separate sessions were held to better accommodate participants' schedules.

Slides of downtown transit centers, transfer facilities, and bus shelters from around the state were shown at the midpoint of each session,

and ratings and comments were solicited. However, for purposes of quantitative analysis, the "core" visual preference survey was limited to one type of facility—bus stops—from one part of the state—South Florida. All stops were photographed from the same angle and distance, near the curb and about 40 feet in front of the stop.¹¹ All slides were taken on sunny days to minimize any effect of weather conditions.¹² We wanted to control for as many extraneous factors as possible.

Viewers were shown a series of paired slides of bus stops (50 pairs in all); slides were paired randomly to avoid the possibility of bias. Viewers were asked to choose the stop from each pair at which they would prefer to wait; asked to rate each stop chosen as a place to wait; and for the first 25 pairs, asked to explain why they chose the stops they did (see the figure on the following page). To minimize fatigue, paired comparisons were divided into two sets of 25 pairs each, separated by a short break.

Slides used in the survey were subsequently analyzed for content; features of the bus stops and their surroundings were measured/quantified for later use as explanatory variables. Three people worked together in an informal Delphi-like process, reaching consensus on assigned values. Nineteen variables were measured/quantified in this manner for each slide. The choice of variables was guided by the literatures on transit-oriented design, urban design, defensible space, and environmental preference.

Visual Preference Survey Format

Pair No. 1:

Preferred stop:

	LEFT		RIGHT		
Rate the preferred stop:	1	2	3	4	5
	wouldn't like to wait there		wouldn't mind waiting there		definitely would like to wait there
Give reason why preferred:					

Examples of stops chosen by most viewers, and given high ratings when chosen, are shown on the following page; stops selected by few viewers, and given low ratings by those few, are also shown.

Finally, statistical techniques were applied to viewers' choices and ratings. Slide ratings were treated as an interval variable, and multiple regression analysis was used to estimate equations of the form:

$$\text{Rating} = B_0 + B_1X_1 + \dots + B_pX_p$$

where the Bs are the parameters being estimated and the Xs are the features of bus stops

and their surroundings that serve as our explanatory variables (listed in the table).

Slide choices had to be analyzed as a nominal variable (a slide either being selected or not, nothing in-between). Binomial logit analysis (logistic regression) was used to estimate a probability function of the form:

$$P(\text{selection}) = \frac{1}{1 + e^{-(B_0 + B_1X_1 + \dots + B_pX_p)}}$$

where P(selection) is the probability of a bus stop being selected in a paired comparison.

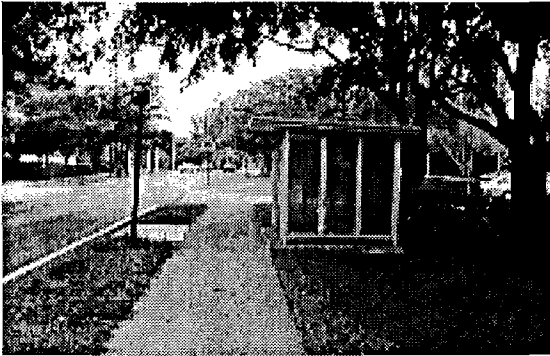
son.¹³ The parameter estimates so derived are those which make the observed results (the choices actually made) most "likely."

Expectations

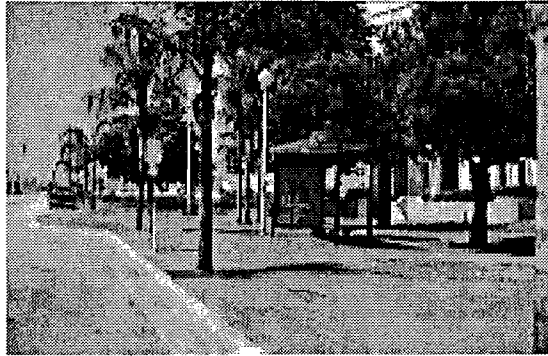
We had some expectations going into the survey:

- Nonusers were expected to react more to scenic qualities of the surroundings than to design features of the bus stops. Like participants in environmental preference surveys, they would likely prefer scenes with lots of

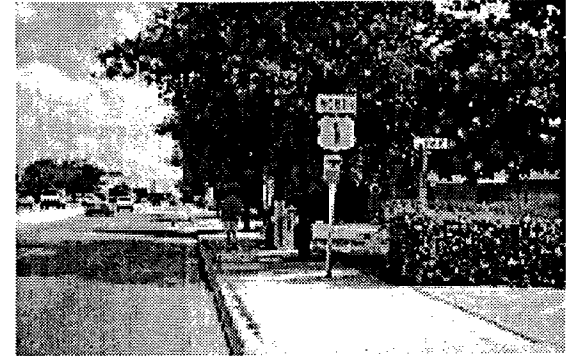
Most Preferred Scenes



Times Chosen - 95%
Average Rating - 3.9



Times Chosen - 89%
Average Rating - 3.9

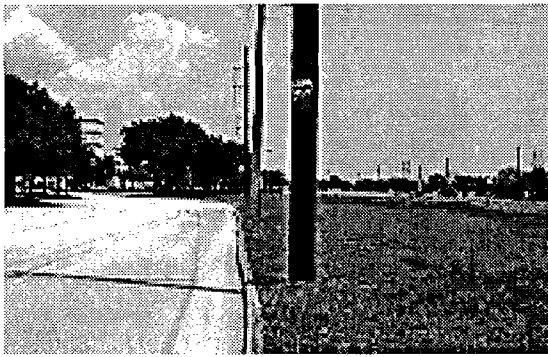


Times Chosen - 97%
Average Rating - 2.6

Least Preferred Scenes



Times Chosen - 27%
Average Rating - 1.6



Times Chosen - 5%
Average Rating - 2.0



Times Chosen - 12%
Average Rating - 1.3

Variables Used in the Regressions

Bus Stop Variables Tested

ADS	=	1 if advertisement is present on bench and/or shelter; 0 otherwise
BENCH	=	1 if the bus stop has a bench but no shelter; 0 otherwise
CARS	=	1 if cars are parked in front of the bus stop; 0 otherwise
CURB	=	1 if the street has a vertical curb at the stop; 0 otherwise
FURNITURE	=	number of different types of street furniture (newspaper boxes, telephones, etc.)
INTERSECTION	=	1 if the bus stop is located at an intersection; 0 otherwise
RIDERS	=	number of users waiting at the stop
SETBACK	=	distance from the bus stop to the street edge (in feet)
SHADE	=	percentage of the bus stop area which is shaded
SHELTER	=	1 if the bus stop has a shelter; 0 otherwise
TURNOUT	=	1 if the bus stop has a turnout; 0 otherwise
WINDOWS	=	1 if windows overlook the bus stop; 0 otherwise

Background Variables Tested

CROSSWALKS	=	total number of crosswalks visible in the background
LANES	=	total number of traffic lanes of abutting street
LIGHT	=	3 if the background lighting is bright; 2 if it is average; 1 if it is dim
PASSERSBY	=	number of people visible in the background
SIDEWALK	=	3 if the sidewalk leading to the bus stop is continuous; 2 if the sidewalk is intermittent; and 1 if there is no sidewalk.
TRAFFIC	=	number of cars clearly visible on the abutting street
TREELINE	=	percentage of street frontage lined by trees
LAND USES:		
MIXED	=	1 if the background has mixed uses; 0 otherwise
NEIGHBORHOOD	=	1 if the background has houses fronting on the street; 0 otherwise
OFFIND	=	1 if the background has offices and/or industry; 0 otherwise
PARKLIKE	=	1 if the background is a park or park-like; 0 otherwise
STOREFRONT	=	1 if the background has stores fronting on the street; 0 otherwise
STRIP	=	1 if the background has stores fronting on a parking lot; 0 otherwise
SUBDIVISION	=	1 if the background has subdivisions backing up to the street; 0 otherwise

Viewer Variables Tested

PLACE	=	1 if the viewer's place of residence is in the suburbs; 0 if it is in the city
SEX	=	1 if the viewer is a male; 0 if female

trees, landscaping, and low-intensity development over those with lots of pavement, cars, and high-intensity development. They might be sensitive to personal security issues, rating scenes with good natural surveillance (from other pedestrians or nearby buildings) higher than those without.

- Transit professionals were expected to focus on the stops themselves, paying less attention to the surroundings. They would be sensitive to operating conditions such as the availability of turnouts for buses, the presence of parked cars (potentially blocking stops), and the location of stops vis-a-vis intersections. They would prefer stops equipped with transit street furniture (benches, shelters, trash containers, etc.), stops with passengers waiting at them, and stops with intense development around them (all of which presage successful operations).

Results

Results of logit analyses for the three viewer groups separately and combined are reported in the table on the next page. Our expectations were not borne out. For the most part, all three groups react to the same features in the same ways. Indeed, when you compare log likelihoods for the three separate runs, to the log likelihood for a combined run, almost no explanatory power is gained by distinguishing among the groups.¹⁴

For all viewers combined, the variables that

most increase the likelihood of a bus stop being chosen are (in order of declining significance based on “asymptotic” t-statistics):

- a bus shelter
- a bus bench (without a shelter)
- trees or an overhang shading the stop
- a vertical curb at the stop
- trees along the street leading to the stop

All these variables are significant and positive for each of the three viewer groups. One additional variable, the presence of advertising on the shelter or bench, is significant and negative for each of the groups.

A slightly different set of variables affect the ratings of chosen bus stops. In this case, the most significant variables are (again, in order of declining significance):

- a bus shelter
- trees along the street leading to the stop
- the setback of the stop from the street edge
- location of the stop at an intersection
- a vertical curb at the stop

As a final way of assessing significance, five variables affect (at the 0.001 level or beyond) both the choices and ratings for all viewers combined.

- a bus shelter
- trees along the street leading to the stop
- a vertical curb at the stop
- the setback of the stop from the street edge
- a continuous sidewalk leading to the stop

Discussion

*Helping people see what they will get usually results in a better building, park, street, highway, park system, downtown, neighborhood, or any of the other components of a town.*¹⁵

Heading into the survey, we had no guarantees that it would produce meaningful results. Bus stop features and background characteristics might have proven insignificant, or worse, entered equations with the “wrong” signs. Yet, both choices and ratings of bus stops suggest relationships that are plausible and consistent.

The results generally conform to the conventional wisdom about transit-oriented design, urban design, defensible space, and environmental preference. So what is gained by doing a visual preference survey? The value of such a survey may lie in its ability to sort out the *most important transit-oriented design features* from the many other, less important features. We cannot do everything or have everything that TOD manuals might prescribe. A visual preference survey may help us choose the best bus stop locations and devote our limited financial re-

Logistic Regression/Multiple Regression Results — (coefficient estimates)

Independent Variables	Analysis of Choices				Analysis of Ratings
	Users	Nonusers	Professionals	All Viewers	All Viewers
ADS	-0.39	-0.57*	-0.66	-0.50**	
BENCH	1.24**	1.57**	1.48**	1.35**	0.15
CARS	-0.80**	-0.65**		-0.67**	-0.23*
CURB	0.54**	0.84**	0.54*	0.69**	0.30**
FURNITURE					
INTERSECTION	-0.35*				0.30**
RIDERS		-0.44**	-0.54**	-0.29**	-0.10*
SETBACK		0.066*		0.050**	0.036**
SHADE	0.014**	0.015*	0.015**	0.015**	
SHELTER	2.63**	3.01**	3.18**	2.79**	0.88**
TURNOUT					0.20*
LANES				0.14*	
LIGHT			-0.37*		
PASSERSBY					0.064*
SIDEWALK	0.18			0.24**	0.15**
TRAFFIC					
TREELINE	0.010**	0.013**	0.012**	0.0099**	0.0046**
MIXED					
NEIGHBORHOOD					
OFFIND					
PARKLIKE		1.47		0.99**	
STOREFRONT				0.32	
STRIP			0.92*		
SUBDIVISION					
PLACE					-0.15**
SEX					
CONSTANT	-2.29**	-2.59**	-1.17*	-3.30**	1.60**
Model Chi-Square	457.7**	385.8**	172.9**	1011.0**	
F-statistic					31.5**
p ² / R ²	0.18	0.22	0.19	0.19	0.17
Number of Cases	1852	1288	660	3800	1812

* Significant at the 0.01 level, one-tailed t-test. ** Significant at the 0.001 level. Others are significant at the 0.05 level.

sources to the most promising bus stop improvements, given the inevitable trade-offs involved.

Also, from quantitative relationships between visual preferences and bus stop features, it should be possible to identify points at which the viewer's utility function peaks or levels off, such points suggesting numerical standards for transit-oriented design. For example, TOD manuals are quite arbitrary in their establishment of minimum bus stop setbacks. Armed with a visual preference survey, we could instead study the independent effect of setback on bus stop selection or rating, and then establish a setback standard at a point where visual preference begins to level off.

ENDNOTES

¹ S. Im, "Visual Preferences in Enclosed Urban Spaces - An Exploration of a Scientific Approach to Environmental Design," *Environment and Behavior*, Vol. 16, 1984, pp. 235-262.

² Some are *urban design manuals* with a transit orientation. Others are *transit facility design manuals* with an urban design orientation. The former emphasize the needs of transit users accessing the system, the latter the needs of the transit operator running the system. Through a nationwide survey of transit agencies, Robert Cervero uncovered 26 sets of design guidelines in place, and 12 under development. We became aware of 10 additional sets through a literature search. R. Cervero, *Transit-Supportive Development in the United States: Experiences and Prospects*, Technology Sharing Program, U.S. Department of Transportation, Washington, D.C., 1993, pp. 27-40; and T.R. Herrero and R. Ewing, *Transit-Oriented Development Guidelines - Review of the Literature*, Florida Department of Transportation, Tallahassee, FL, 1993.

³ R.E. Knack, "Tony Nelessen's Do-It-Yourself Neotraditionalism," *Planning*, Vol. 57, December 1991, pp. 18-22; and A.C. Nelessen, *Visions for a New American Dream*, American Planning Association, Chicago, IL, 1994.

⁴ Environmental preference surveys dating back to the late 1960s are reviewed in L.M. Arthur, T.C. Daniel, and R.S. Boster, "Scenic Assessment: An Overview," *Landscape Planning*, Vol. 4, 1977, pp. 109-129; R.S. Ulrich, "Aesthetic and Affective Response to Natural Environment," In I. Altman and J.F. Wohlwill (eds.), *Behavior and the Natural Environment*, Plenum Press, New York, 1983, pp. 85-125; H.W. Schroeder, "Environment, Behavior, and Design Research on Urban Forests," In E.H. Zube and G.T. Moore (eds.), *Advances in Environment, Behavior, and Design - Volume 2*, Plenum Press, New York, 1988, pp. 87-117; and R. Kaplan and S. Kaplan, *The Experience of Nature - A Psychological Perspective*, Cambridge University Press, New York, 1989, pp. 216-291. Design-oriented surveys, more akin to our survey, include: G.S. Shaffer and L.M. Anderson, "Perceptions of the Security and Attractiveness of Urban Parking Lots," *Journal of Environmental Psychology*, Vol. 5, 1983, pp. 311-323; T.R. Hudspeth, "Vi-

sual Preference as a Tool for Facilitating Citizen Participation in Waterfront Revitalization," *Journal of Environmental Management*, Vol. 23, 1986, pp. 373-385; and J.L. Nasar, "The Effect of Sign Complexity and Coherence on the Perceived Quality of Retail Scenes," *Journal of the American Planning Association*, Vol. 53, 1987, pp. 499-509.

⁵ H.W. Schroeder, "Environmental Perception Rating Scales: A Case for Simple Methods of Analysis," *Environment and Behavior*, Vol. 16, 1984, pp. 573-598.

⁶ Im, *op. cit.*; R.E. Coughlin and K.A. Goldstein, *The Extent of Agreement Among Observers on Environmental Attractiveness*, Regional Science Research Institute, Philadelphia, PA, 1970; K.H. Craik, "Psychological Factors in Landscape Appraisal," *Environment and Behavior*, Vol. 4, 1972, pp. 255-266; E.L. Shafer and T.A. Richards, *A Comparison of Viewer Reactions to Outdoor Scenes and Photographs of Those Scenes*, Northeast Forest Experimental Station, USDA Forest Service, Upper Darby, PA, 1974; E.H. Zube, "Cross-Disciplinary and Intermode Agreement on the Description and Evaluation of Landscape Resources," *Environment and Behavior*, Vol. 6, 1974, pp. 69-89; T.C. Daniel and R.S. Boster, *Measuring Landscape Esthetics: The Scenic Beauty Estimation Method*, Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, Fort Collins, CO, 1976, pp. 48-51; G.J. Buhyoff, W.A. Leuschner, and L.K. Arndt, "Replication of a Scenic Preference Function," *Forest Science*, Vol. 26, 1980, pp. 227-230; and S. Shuttleworth, "The Use of Photographs as an Environmental Presentation Medium in Landscape Studies," *Journal of Environmental Management*, Vol. 11, 1980, pp. 61-76.

⁷ T.R. Herzog, S. Kaplan, and R. Kaplan, "The Prediction of Preference for Unfamiliar Urban Places," *Population and Environment*, Vol. 5, 1982, pp. 43-59; T.R. Herzog, "A Cognitive Analysis of Preference for Waterscapes," *Journal of Environmental Psychology*, Vol. 5, 1985, pp. 225-241; and T.R. Herzog, "A Cognitive Analysis of Preference for Urban Nature," *Journal of Environmental Psychology*, Vol. 9, 1989, pp. 27-43.

⁸ Is it the narrow streets, straight alignments, small setbacks, mature trees, vernacular architecture, or some com-

bination of these and other design features that cause traditional scenes to be preferred? We cannot be sure until we analyze the relationships between individual design features and viewer preferences.

⁹ See, for example, E.L. Shafer, "Perception of Natural Environments," *Environment and Behavior*, Vol. 1, 1969, pp. 71-82; E.G. Carls, "The Effects of People and Man-Induced Conditions on Preferences for Outdoor Recreation Landscapes," *Journal of Leisure Research*, Vol. 6, 1974, pp. 113-124; T.R. Herzog, S. Kaplan, and R. Kaplan, "The Prediction of Preference for Familiar Urban Places," *Environment and Behavior*, Vol. 8, 1976, pp. 627-645; D.J. Briggs and J. France, "Landscape Evaluation: A Comparative Study," *Journal of Environmental Management*, Vol. 10, 1980, pp. 263-275; P. Dearden, "A Statistical Technique for the Evaluation of the Visual Quality of the Landscape for Land-Use Planning Purposes," *Journal of Environmental Management*, Vol. 10, 1980, pp. 51-68; J.L. Nasar, "A Model Relating Visual Attributes in the Residential Environment to Fear of Crime," *Journal of Environmental Systems*, Vol. 11, 1981-82, pp. 247-255; L.M. Anderson and H.W. Schroeder, "Application of Wildland Scenic Assessment Methods to the Urban Landscape," *Landscape Planning*, Vol. 10, 1983, pp. 219-237; H.W. Schroeder and L.M. Anderson, "Perception of Personal Safety in Urban Recreation Sites," *Journal of Leisure Research*, Vol. 16, 1984, pp. 178-194; J.N. Lien and G.J. Buhyoff, "Extension of Visual Preference Models for Urban Forests," *Journal of Environmental Management*, Vol. 22, 1986, pp. 245-254; and R.S. Ulrich, "Human Responses to Vegetation and Landscapes," *Landscape and Urban Planning*, Vol. 13, 1986, pp. 29-44.

¹⁰ Stated preference surveys, widely used in transportation research, ask respondents to rate, rank, or choose between alternatives described in terms of salient features (for example, alternative modes characterized by travel time, out-of-pocket cost, and presence or absence of transfers). The descriptions are either verbal or in writing, with no visual component. In this sense, stated preference surveys lag behind visual preference surveys. However, the methods used to analyze results of stated preference surveys and test their validity are more sophisticated than those commonly used in visual preference surveys. This is an interesting case study in the tendency of different fields to de-

velop their own approaches to parallel problems with a minimum of cross-fertilization. See, for example, E.P. Kroes and R.J. Sheldon, "Stated Preference Methods - An Introduction," *Journal of Transport Economics and Policy*, Vol. 22, 1988, pp. 11-26; M. Wardman, "A Comparison of Revealed Preference and Stated Preference Models of Travel Behaviour," *Journal of Transport Economics and Policy*, Vol. 22, 1988, pp. 71-91; W.P. Beaton, "Assessing the Effectiveness of Transportation Control Measures: Use of Stated Preference Models to Project Mode Split for Work Trips," *Transportation Research Record* 1346, 1992, pp. 44-52; D. Anderson, "Estimating Availability Effects in Travel Choice Modeling: A Stated Choice Approach," *Transportation Research Record* 1357, 1992, pp. 51-65; A.J. Khattak, F.S. Koppelman, and J.L. Schofer, "Stated Preferences for Investigating Commuters' Diversion Potential," Paper presented at the 73rd Annual Meeting, Transportation Research Board, Washington, D.C., 1992; J.D. Hunt, J.D.P. McMillan, and J.E. Abraham, "A Stated Preference Investigation of Influences on the Attractiveness of Residential Locations," Paper presented at the 73rd Annual Meeting, Transportation Research Board, Washington, D.C., 1994; and J. Polak and P. Jones, "A Tour-Based Model of Journey Scheduling Under Road Pricing," Paper presented at the 73rd Annual Meeting, Transportation Research Board, Washington, D.C., 1994.

¹¹ This vantage point takes in the stop itself plus: one side of the street up close and the entire streetscape in the distance; the sidewalk and any cross streets on the bus stop's side; the land use immediately to the rear of the stop; and the background land uses for some distance.

¹² Even shooting photos only on sunny days, slides varied in brightness. A brightness variable was tested in all logit and multiple regression analyses and proved significant in only one analysis, that of choices made by transit professionals.

¹³ See the literature on logit analysis or the literature on logistic regression analysis, e.g., J. Aldrich and F. Nelson, *Linear Probability, Logit, and Probit Models*, Sage Publications, Beverly Hills, CA, 1984; M. Ben-Akiva and S.R. Lerman, *Discrete Choice Analysis: Theory and Application to Travel Demand*, MIT Press, Cambridge, MA, 1985; and D.W. Hosmer and S. Lemeshow, *Applied Logistic Regression*, John Wiley & Sons, New York, 1989.

¹⁴ The difference between -2 times the log likelihood of the combined run and -2 times the sum of log likelihoods for the individual runs follows a chi-square distribution, with the number of degrees of freedom equal to the number of estimated coefficients in the three individual equations less the number in the combined equation. In this case, the difference is only 5.4, with 17 degrees of freedom, which is not a significant difference.

¹⁵ American Institute of Architects, *Design Your Town*, Washington, D.C., 1992, p. 7.

Appendix B

Mode Share Analysis - Land Use Influences

This appendix describes the first of two studies of transit ridership in Metropolitan Dade County, Florida, the county surrounding Miami. The studies together tell us which land use and urban design variables significantly affect transit ridership, either alone or in combination with one another. For the significant variables, we can estimate threshold values corresponding to desired levels of transit productivity and/or farebox recovery. Threshold values can then be used as a guide to transit-oriented development in the Sunbelt.

What We Know Already

There is no shortage of studies relating land use and urban design to transit ridership. Studies range from simple correlations of transit ridership and residential density to sophisticated multivariate studies that control for multiple influences on transit ridership.

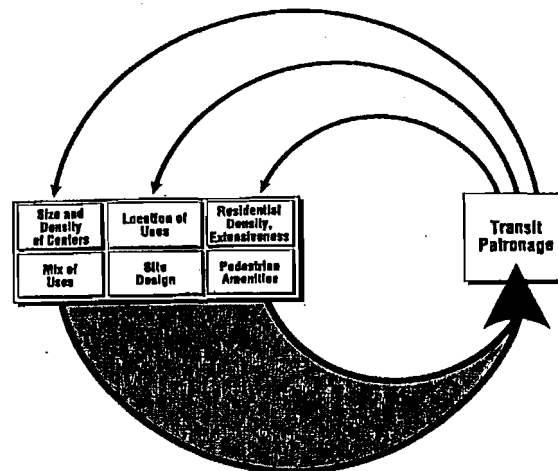
(1) Simple Correlation Studies

At least six studies report direct relationships between *residential density* and transit ridership or transit mode split.¹ Three studies have found that *mixed land uses* generate more transit trips than does any single use by it-

self.² Two studies have shown that pedestrian-friendly *urban design* boosts transit's mode share.³ Three studies report that older neighborhoods have higher transit mode shares than new neighborhoods, a result attributed in part to the former's grid-like *street networks* (which facilitate transit access and make transit routing more direct).⁴

The only catch is that the various land use and urban design features believed to encour-

*Transit and Development: Causality
(as posited in the literature)*



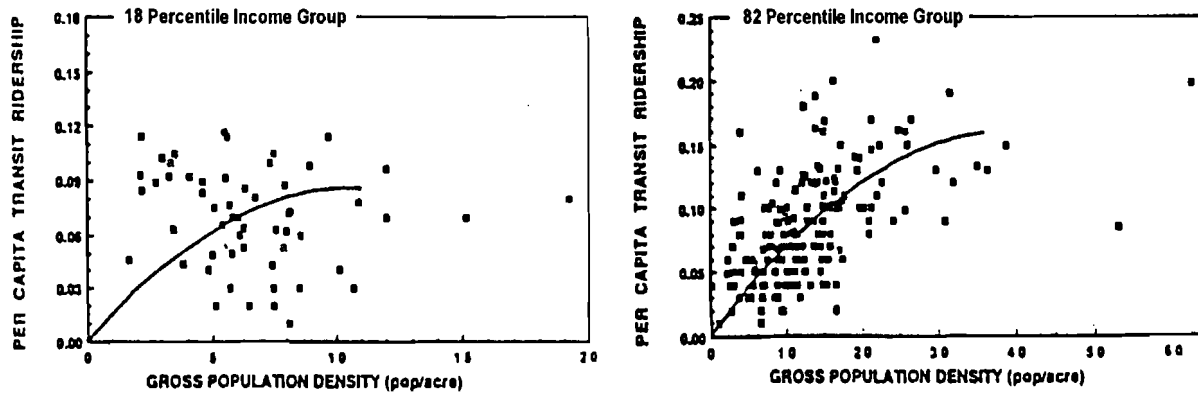
Source: Parsons Brinckerhoff Quade & Douglas, *Transit and Urban Form - Phase I Report*, Transit Cooperative Research Program, Transportation Research Board, Washington, D.C., 1994, p. 54.

age transit ridership usually go hand-in-hand. It is unclear whether higher densities, finer land use mixes, pedestrian-friendly designs, and/or gridded streets are responsible for elevated transit ridership in older urban neighborhoods. We would like to know because some of these features are more politically palatable and transferable to the suburbs than are others.

Moreover, the places where these features appear usually also have transit-dependent populations and better-than-average transit service levels. In this "chicken and egg" world, it is unclear whether elevated ridership is due to land use and design, socioeconomic and transit service levels, or some combination of the above. If this added ridership is entirely due to socioeconomic and transit service levels, we might as well forget the whole idea of transit-oriented development.

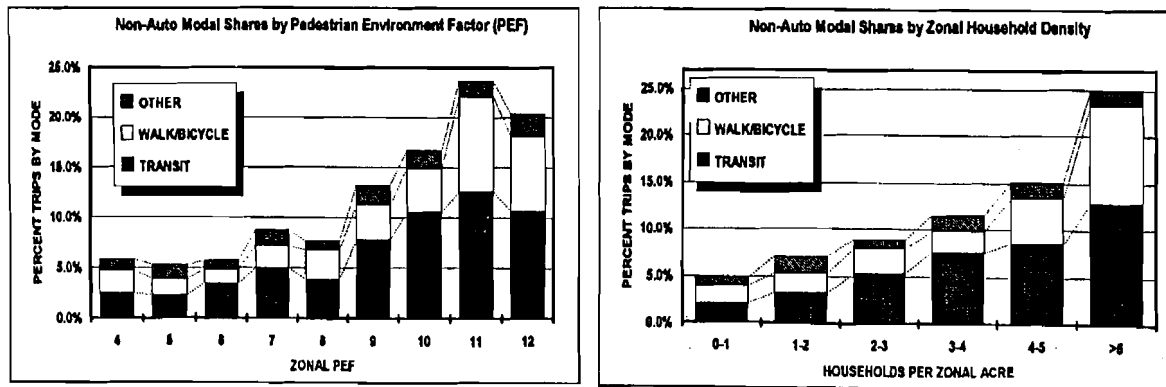
Most (not all) earlier studies fail to acknowledge such interrelationships, a fact apparent in the following figures (reproduced from earlier studies). The simple relationships depicted between specific land use/urban design variables and transit use are, in fact, complicated by other, uncontrolled variables.

*Effect of Density on Transit Ridership
(Partially Controlling for One Other Factor, Average Income)*



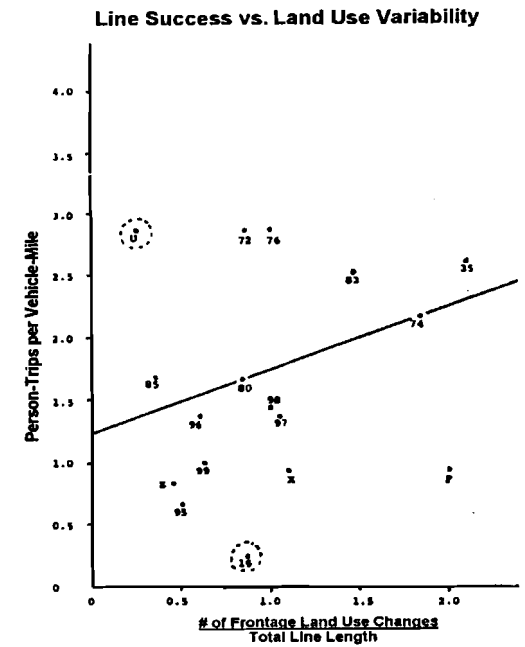
Source: R.J. Spillar and G.S. Rutherford, "The Effects of Population Density and Income on Per Capita Transit Ridership in Western American Cities," *ITE 1990 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1990, pp. 327-331.

Not-So-Independent Effects of Density and Pedestrian Environment



Source: Parsons Brinckerhoff Quade Douglas, Inc., *The Pedestrian Environment - Volume 4A*, 1000 Friends of Oregon, Portland, OR, 1993, pp. 18 and 23.

*Effect of Land Use Variation Along
Transit Lines
(But How About Density?)*



Source: R. Tomazinis et al., *A Study on Factors Affecting Success of Suburban Mass Transit Lines*, Urban Mass Transportation Administration, Washington, D.C., 1979, p. 84.

(2) Multivariate Studies

Five studies are noteworthy for their multivariate analyses. A remarkable (and largely forgotten) study of travel patterns in eight metropolitan areas explained transit's share of total vehicle trips in terms of socioeconomic, land use, and transportation service variables.⁵ Distance to the central business district (CBD) proved highly significant, as did neighborhood density, even after controlling for race, auto ownership, income, transit availability, and average auto speed. This is as close to an unequivocal result as you will find in the land use-travel literature.

A Seattle study modeled mode shares in terms of socioeconomic, land use, and transportation service variables.⁶ For work trips, the only land use variable significantly related to bus mode share was the average employment density of origin and destination census tracts. Once that variable entered the regression equation, land use mix and population density (which have simple correlations with bus use) had no additional explanatory power. For shopping trips, both employment and population densities entered at statistically significant levels; variables representing the degree of land use mixing did not enter.

A national demonstration project in Portland, Oregon, modeled mode choice in terms of socioeconomic, land use, transportation service, and one urban design variable, the "pedestrian environment factor."⁷ Variables affecting transit mode choice differed between walk

and auto access modes, and between work and other trip purposes. The pedestrian environment factor was significant consistently, as was the level of employment within a mile of origin or destination zones. However, residential densities of zones proved significant in only one equation, and employment densities proved insignificant in all equations, after controlling for other variables.

A study of office sites in San Francisco sought to explain rail's share of work trips in terms of occupational, land use, and urban design variables.⁸ Distance to a rail station proved most significant; employment density around the station was also significant. With these variables accounted for, eight urban design variables ("indicators of walking quality") failed to enter the mode share equation.

An analysis of transit mode choices by residents of five San Francisco neighborhoods considered personal attitudes as well as socioeconomic, land use, and transit access variables.⁹ Not including the attitudinal variables, the best-fit equation contained several socioeconomic variables, a proxy for residential density, and distance to the nearest rail station. A dummy variable representing mixed-use neighborhoods did not enter any of the travel equations. Personal attitudes toward the environment, transit, etc. were quite strongly associated with travel choices, more so in fact than were land use variables (an interesting fact that may limit the impact of land use changes on travel choices).

Clearly, when the effects of other variables are controlled, the apparently straightforward relationships between land use/urban design variables and transit use become fuzzier.

What We Would Like to Know

Only two previous multivariate studies have tested urban design variables, and these with varying results. Only two have tested land use mix, again with varying results. No previous multivariate study has tested road network variables *per se*.

Perhaps more importantly, no previous study, including the five multivariate studies, has allowed the various socioeconomic, land use, urban design, and transit service variables to interact. Explanatory variables have been treated as independent when, in fact, they almost certainly have combined effects on transit ridership that are more (or less) than the sum of the parts. For example, improvements in transit service may have little effect in auto-rich areas but a large effect in auto-poor ones.

The ultimate empirical study would control for socioeconomic and transportation service variables, while examining the independent effects of land use and urban design variables on transit use. It would capture the interactions of socioeconomic and land use variables, land use and urban design variables, and so forth rather than treating all explanatory variables as independent. Using a large and disaggre-

gated data base, the study would fit a function of the form:

*Transit Mode Share = Function (Socioeconomic Variables, Land Use Variables, Urban Design Variables, Road Network Variables, Transportation Service Variables)*¹⁰

What We Did

While the study reported in this appendix falls short of the ideal outlined above, it comes as close as data permit. We model all classes of explanatory variables except urban design variables. In Appendix C, urban design variables are modeled as well. In this chapter, interaction effects are captured in two ways: first, by constructing new variables as multiplicative products of existing variables; and second, by representing the interrelationships among variables in sets of equations that are estimated simultaneously.

(1) Data Sources

Metropolitan Dade County was chosen as a study area because it is the only place in Florida with much in the way of transit service or transit ridership. All data are for the same time period, early 1990 at the time of the U.S. Census of Population and Housing. All data are at the same level of geographic detail, the traffic analysis zone.

For most purposes, travel data for individual households are superior to data for traffic analy-

sis zones. Much of the variation in household travel behavior (and the information contained in household travel records) is lost when data are aggregated to the zone level.¹¹ We would only note that with small transit mode shares, standard-size travel surveys may record too few transit trips for statistical purposes. Whatever its other limitations, at least the U.S. Census, upon which we rely, gathers journey-to-work data from a huge sample of households. The journey-to-work data used in this study are at the finest level of geographic detail (the traffic analysis zone) ever compiled by the U.S. Census Bureau.

Mode shares for work trips to and from traffic analysis zones were extracted from the 1990 Census Transportation Planning Package for Dade County. Socioeconomic, land use, and parking price data came from files prepared by the Dade County Planning Department for use in regional travel demand forecasting. Road network data were compiled from detailed zone maps; ratings were assigned to networks on a scale of 1 to 5 (from most to least grid-like). Transit service and route data came from the transit route map in effect at the time of the 1990 U.S. Census of Population and Housing. Walk access times and bus travel times to downtown were from travel time "skims" generated by the regional travel model.

We started with 1164 zones for all of Dade County. Many TAZs were eliminated because they generated no work trips in 1990. Other TAZs had to be dropped for lack of complete sets of explanatory variables.¹² Our final

samples consisted of 690 zones with work trip productions and 698 zones with work trip attractions; for these zones, all variables have defined values.

(2) Dependent Variables

The Census Transportation Planning Package enumerates work trips between pairs of zones, making it possible to aggregate by place of residence or place of work. We aggregated both ways and would expect transit ridership determinants to differ between them. Socioeconomics of resident households will certainly affect mode shares by place of residence but should not by place of work. Employment mix should affect mode shares by place of work but may not by place of residence.

The U.S. Census distinguishes among transit modes (bus, streetcar or trolley, subway or elevated, etc.). Here, we focus on bus use because bus service is the rule, rail the exception, in Florida. Even in rail-served Dade County, bus ridership exceeded rail ridership in 1990 by a factor of more than 5-to-1. Also from exploratory modeling at the outset of the project, the bus mode share appears far more predictable than the rail share.

$BUSSHARE_{home}$ and $BUSSHARE_{work}$ represent bus mode shares for zones of residence and employment, respectively.

(3) Explanatory Variables

Five types of variables were used to model bus mode shares. Like mode shares, all variables relate to traffic analysis zones.

Socioeconomic variables

O/1-AUTOS = proportion of households with 0 or 1 automobiles

INCOME = median household income in thousands, where midpoints of income ranges were used in the absence of actual median values

MULTIFAMILY = proportion of multifamily dwellings in the local housing stock

Land use variables

LOG-OVERDEN = \log_{10} [(total population + total employment)/land area in square miles]

The use of overall density was dictated by data limitations. We could not compute net densities because only total land areas of zones were known (not areas devoted to different land uses). We could have computed gross residential and gross employment densities, but gross densities have little meaning in mixed-use zones. We took the logarithm of overall density to reduce the skewing effect of "outliers," that is, data points well beyond the normal density range, mainly downtown zones with extremely high employment densities.

BAL-MIX = $1 - [Absolute\ Value\ (total\ employment - 1.5 \times total\ housing\ units)] / (total\ employment + 1.5 \times total\ housing\ units)$

This mixed-use variable ranges from 0 to 1, depending on the degree of jobs-housing balance. It assumes a value of 1 when jobs and housing are in nominal balance and 0 when only jobs or housing units are present, not both. A nominal balance is taken as 1.5 jobs per housing unit.

DEGREE-MIX = $\{[housing\ units \times \log_{10}(housing\ units)] + [retail\ jobs \times \log_{10}(retail\ jobs)] + [service\ jobs \times \log_{10}(service\ jobs)] + [industrial\ jobs \times \log_{10}(industrial\ jobs)]\} / (housing\ units + retail\ jobs + service\ jobs + industrial\ jobs)$

This mixed-use variable is an adaptation of an "entropy" variable tested in earlier land use-travel studies.¹³ Holding the total activity level constant, this variable will assume a higher value where there is less land use mixing, a lower value where there is more mixing.

COMM-SERV = proportion of local jobs in commercial and service sectors

This variable accounts for differences in transit trip generation between commercial/service and industrial sectors.

Road network variables

GRID = 1 for pure grid or grid-like networks, 0 otherwise

This dummy variable assumes a value of 1 for pure grids or near-grids (networks rated 1 or 2 on the 1-5 scale described previously -- see examples below).

NONGRID = 1 for discontinuous networks, 0 otherwise

This variable assumes a value of 1 for highly interrupted grids or curvilinear networks with few through-streets (networks rated 4 or 5 on the 1-5 scale described previously -- see examples below).

Transit service variables

LOG-RTDEN = \log_{10} (number of local bus routes/land area in square miles)

The logarithm of route density was taken, as above, to reduce the skewing effect of outlying data points. The outliers are downtown zones with extremely high route densities in Miami's downtown-oriented bus system.

PEAK-FREQ = average peak frequency for local bus routes

This is the average number of peak-hour runs per route for all routes traversing a zone.

BUS-TIME = peak-hour run time by bus to downtown Miami (in minutes)

This is the best available proxy for regional transit accessibility (that is, accessibility to ac-

tivities region-wide via transit). It serves as a decent proxy thanks to the downtown orientation of Miami's bus system.

WALK-TIME = average walk access time to or from the closest bus route (in minutes)

This is rough estimate based on the size and geometry of zones and the alignment of routes.

RAIL = 1 for zones with Metrorail lines running through them, 0 otherwise

This dummy variable was included to account for competition or complementarity between bus and rail modes.

Other variables

PARKING\$ = average long-term (seven-hour) parking charge within the zone (in dollars)

DOWNTOWN = 1 for downtown zones, 0 otherwise

PRODUCT1 = 0/1-AUTOS x LOG-RTDEN

PRODUCT2 = *PARKING\$* x LOG-RTDEN

The last two variables are products of other variables, included to test for multiplicative effects. Neither variable added significantly to the explanatory power of the equations estimated.

(4) Initial Runs

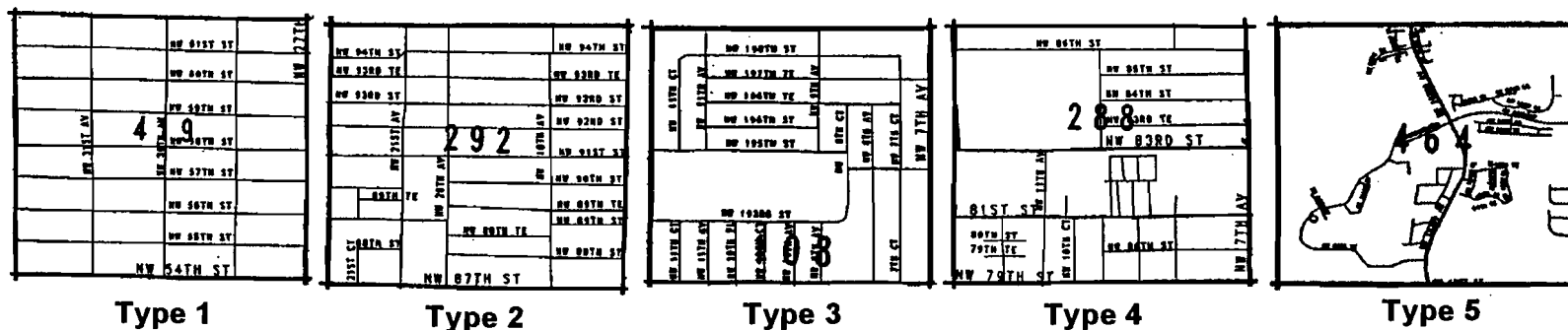
The analysis of bus mode share by place of residence began with the estimation of a single equation using stepwise regression analysis (ordinary least squares). The first variable to enter the regression equation was the proportion of households with 0 or 1 automobiles (0/1-AUTOS); the second was median household in-

come (*INCOME*); the third was bus travel time to downtown (*BUS-TIME*); the fourth was average peak frequency of bus service (*PEAK-FREQ*); the fifth was jobs-housing balance (*BAL-MIX*); and last was the Metrorail dummy variable (*RAIL*). All variables had the expected signs and all were significant at or beyond (in some cases far beyond) the 0.05 level commonly used in statistical analysis.

These results would be cause for rejoicing but for the fact that the logarithm of overall density (*LOG-OVERDEN*) never entered the regression equation. Even worse, it came close to entering with the "wrong" sign (a - sign, implying that higher density depresses bus use).

The reason for this anomaly became clear when we regressed the proportion of households with 0 or 1 automobiles (0/1-AUTOS) on the logarithm of overall density (*LOG-OVERDEN*) and

Road Networks Rated as More or Less Grid-Like (scale of 1 to 5)



other variables. Now, *LOG-OVERDEN* entered with the expected sign (+) at a high level of statistical significance. Thus, it appears that the relationship between density and bus use is indirect; as density rises, auto ownership falls; as auto ownership falls, bus use rises. Treating the relationship as direct only leads to spurious results.

(5) Change of Method

Conceptualized this way, auto ownership becomes an "endogenous" variable (that is, a variable determined by other variables in a system of equations, not pre-determined outside the system). Indeed, one could argue that other variables, particularly transit service variables, are also endogenous to this system. Presumably, better transit service is supplied to areas where there are more transit dependents within walking distance of stops.

Thus, we chose to model bus mode share with a system of three equations. To our knowledge, this is the first time transit use has been modeled this way. Such a system cannot be estimated using ordinary least squares regression. When equations are interrelated as these are, ordinary least squares will overestimate equation coefficients and significance levels of endogenous variables used as explanatory variables.¹⁴ The result will be inconsistent estimates of coefficients, that is, estimates that are biased even for large samples.

To obtain consistent coefficient estimates, we must use a statistical method that accounts

for interactions among endogenous variables (endogenous variables both determining and being determined by one another). Here, the basic choice is between limited-information and full-information methods. The former, which include the popular *two-stage least squares* method, are much more frequently applied than are the latter due to their computational simplicity and relative insensitivity to equation specification errors. Yet, if equations are correctly specified (with all the right variables in the right mathematical form), full-information methods will yield more efficient estimates of equation coefficients (i.e., estimates that on average come closer to the true values of the coefficients being estimated). They can produce more efficient estimates because full-information methods take into account all available information—including the mathematical forms of other equations in the system—when estimating the values of coefficients in any given equation.

We chose the *full-information maximum likelihood* (FIML) method to estimate our system of equations simultaneously. FIML is not used much in econometric modeling, mainly because common applications are too complex. Econometric models of a regional or national economy may contain scores of equations in countless variables and only a few dozen time periods for which data are available. We, on the other hand, have few equations, few variables, and data for hundreds of traffic analysis zones to ensure consistent coefficient estimates.

(6) Results by Place of Residence

The relative simplicity of our system of equations allowed us to test many different combinations of variables on the way to an optimal model structure. The following equations, simultaneously estimated with FIML, proved optimal in terms of explanatory power (R^2 's), coefficient significance levels (t-statistics in parentheses), and coefficient signs (as expected in all cases).

$$\text{BUSSHARE}_{\text{home}} = -0.14 + 0.32 \times 0/1\text{-AUTOS} + 0.024 \times \text{BAL-MIX} + 0.0064 \times \text{PEAK-FREQ} \quad (13.7)$$

$$R^2 = 0.34$$

$$0/1\text{-AUTOS} = 0.26 - 0.0064 \times \text{INCOME} + 0.14 \times \text{LOG-OVERDEN} - 0.0017 \times \text{BUS-TIME} \quad (9.0)$$

$$R^2 = 0.58$$

$$\text{LOG-RTDEN} = -1.03 + 1.32 \times 0/1\text{-AUTOS} + 0.33 \times \text{LOG-OVERDEN} + 0.13 \times \text{GRID} + 0.091 \times \text{RAIL} \quad (10.1)$$

$$R^2 = 0.49$$

Results can be interpreted as follows. Bus mode share for work trips depends largely (but not entirely) on the proportion of households with no automobile or only one automobile. A

reasonable balance of jobs and housing will boost bus use somewhat, presumably due to the ability of bus users to complete errands on the way to and from work (much as auto users link trips on their way to and from work). Frequent bus service will also boost bus use, as more autoless workers take the bus (rather than some alternative such as a carpool) and as some auto-owning workers choose the bus over the automobile. But auto availability appears far more significant as a determinant of bus use than does any other factor.

The proportion of 0/1 auto households is higher where incomes are low, and also where overall density is high and transit access to downtown is good. High densities make automobile ownership and use less attractive (due to traffic congestion and limited parking). Good regional transit accessibility permits households to “shed” an automobile, that is, function with one rather than two or more autos.

Bus routes are dense where auto ownership is limited and overall densities are high. The combination of limited auto ownership and dense development places more transit dependents within walking distance of bus stops, something a transit agency naturally responds to in its service planning. Bus routes are also denser where streets are grid-like, making bus operations potentially more efficient, and where rail lines run through the area, placing bus routes in the role of feeder services.

Note that there is no feedback between the third equation and the first. Neither *GRID* nor *LOG-RTDEN* could be incorporated into the *BUSSHARE_{home}* equation without sacrificing goodness-of-fit.

(7) Results by Place of Work

Bus mode share by place of work proved easier to model than did bus mode share by place of residence, but the resulting models were less satisfactory in terms of explanatory power. For places of work, ordinary least squares regression produced plausible results:

$$\begin{aligned} \text{BUSSHARE}_{\text{work}} &= 0.003 + 0.014 \times \text{LOG-OVERDEN} && (2.2) \\ &- 0.00023 \times \text{BUS-TIME} + 0.009 \times \text{PARKING\$} && (-3.9) \quad (4.2) \\ R^2 &= 0.12 \end{aligned}$$

First, the good news. All explanatory variables, including overall density, have the expected signs. The not-so-good news is that the explanatory power of all variables taken together is quite limited (the R^2 indicating that only 12% of the variation in bus mode share is explained by the model).

We also tried modeling *BUSSHARE_{work}* via a system of equations like that used to model *BUSSHARE_{home}*. Once again, the relationship between land use variables and bus use was conceived as indirect, with land use variables acting through an intervening variable to affect bus use.

The key intervening variable in this case was the average long-term parking charge in the zone of employment (*PARKING\$*). It functioned just as the proportion of households with 0 or 1 automobiles (*0/1-AUTOS*) did in the analysis of mode share by place of residence, influencing mode share and being influenced by density. The following system of equations provided the best fit:

$$\begin{aligned} \text{BUSSHARE}_{\text{work}} &= 0.061 - 0.00026 \times \text{BUS-TIME} + && (-4.4) \\ &0.011 \times \text{PARKING\$} && (3.5) \\ R^2 &= 0.11 \\ \text{PARKING\$} &= -4.34 + 1.07 \times \text{LOG-OVERDEN} + && (16.4) \\ &2.95 \times \text{DOWNTOWN} + 0.36 \times \text{COMM-SERV} && (27.6) \quad (1.4) \\ R^2 &= 0.38 \end{aligned}$$

Whether referring to the single equation or the system of two equations, bus mode shares depend primarily on average long-term parking charges and bus travel times to downtown. Paid parking is the one factor that can tip overall travel costs in favor of transit for workers who have access to automobiles; a short bus time to downtown means relatively good transit access to regional employment. In the system of two equations, overall density affects bus mode share only through its effect on parking charges. In the single equation, overall density has an independent effect on bus mode share beyond that of parking charges.

Both models have an air of plausibility about them. Both will be used in our later work.

(8) Density Thresholds for Bus Service

To illustrate how these equations might be applied, we refer to Metro-Dade County Transit Agency's *Service Planning Guidelines*. The guidelines state that transit productivity on every route shall be at least half the weighted average for the entire system. The weighted average for the entire system is 32.8 passenger trips per revenue-hour, which corresponds to 2.6 trips per revenue-mile. The minimum productivity is thus 1.3 trips per revenue-mile.

With 11.7 routes per square mile (the average for all zones in our sample), 16 hours of service per day, and 25-minute headways between buses in each direction (the average for this system), a square mile of land area must generate 1,168 bus trips per day to maintain a productivity of 1.3 trips per revenue-mile.

Bus trips per square mile (*BUS-TRIPS*) are given by the equation:

$$BUS-TRIPS = BUSSHARE \times TRIP-RATE \times OVERDEN$$

where *BUSSHARE* is the bus mode share within the square mile area, *TRIP-RATE* is the average trip rate per person or employee, and *OVERDEN* is the overall density of persons or employees. For predominantly residential zones, we will use a trip rate of 2.5 trips per person per

day and assume that the overall bus mode share is equal to $0.5 \times BUSSHARE_{home}$. *BUSSHARE_{home}* is the bus share of work trips by place of residence; it is the dependent variable in one of our earlier analyses. Multiplying by 0.5 adjusts for transit's ability to capture a greater share of work trips than trips for other purposes (the mode share on work trips is twice the overall share). Recall that our mode share equations apply only to work trips since U.S. Census data were available only for the journey to work.

Substituting these values into the preceding equation, we obtain:

$$BUS-TRIPS = 1.25 \times BUSSHARE_{home} \times OVERDEN$$

Let's return now to the system of three interrelated equations for *BUSSHARE_{home}*, presented earlier in this report. Substituting the equation for *O/I-AUTOS* into the equation for *BUSSHARE_{home}*, we have:

$$BUSSHARE_{home} = -0.06 - 0.002 \times INCOME + 0.045 \times LOG-OVERDEN - 0.00054 \times BUS-TIME + 0.024 \times BAL-MIX + 0.0064 \times PEAK-FREQ$$

Finally, substituting this equation into the *BUS-TRIPS* equation, we arrive at an expression for total bus trips generated within a square mile area in terms of exogenous variables only (including *OVERDEN*, the variable of interest here):

$$BUS-TRIPS = 1.25 \times OVERDEN \times (-0.06 - 0.002 \times INCOME + 0.045 \times LOG-OVERDEN - 0.00054 \times BUS-TIME + 0.024 \times BAL-MIX + 0.0064 \times PEAK-FREQ)$$

Using zonal average values of *INCOME*, *BUS-TIME*, *BAL-MIX*, and *PEAK-FREQ*, we find by trial and error that the *OVERDEN* required to generate 1,168 bus trips per day (thereby meeting the minimum transit service planning guideline) is 14,700 persons per square mile. At 2.75 persons per household, this is equivalent to 8.4 dwellings per acre.

If other variables in the preceding equation assume values significantly above or below the sample averages, the overall density required to meet the guideline rises or falls accordingly. Areas with below-average incomes, for example, can meet the guideline at lower overall densities than can areas with above-average incomes.

The relationship between required density and bus service frequency is particularly interesting. An increase in service frequency boosts the bus mode share (through the influence of *PEAK-FREQ*) but also increases the number of bus trips that must be generated to meet the minimum productivity guideline (since more runs are made at higher frequencies). On balance, holding all other variables constant, a shift from 25-minute to 15-minute headways would increase the required density from 14,700 to 19,500 persons per square mile (or 8.4 to 11.1 dwellings per acre).

Parallel calculations could be performed for zones that are predominantly nonresidential using the equations for bus mode share by place of work (*BUSSHARE_{work}*).

What We Learned

Findings of this study germane to transit-oriented development are:

- Different factors affect transit ridership at the home and work ends of work trips. Predominantly residential areas should be evaluated for ridership potential using one set of mode share equations, predominantly commercial areas evaluated using the other set. Mixed-use areas should be evaluated with respect to both sets since they may qualify for bus service either as places producing trips or places attracting trips.
- Bus mode share by place of residence is primarily related to auto ownership, and secondarily to jobs-housing balance and bus service frequency. Auto ownership, in turn, is related to household income, overall density, and transit access to downtown. Thus, all three types of variables—*sociodemographic*, *land use*, and *transit service*—affect bus use through a web of interrelationships.
- Road network design has no apparent effect on bus use, though it does affect the density of bus routes supplied to an area. Pure grids and near-grids (those rated 1 or 2 on our 1-5 scale) have more routes per square mile, perhaps reflecting the greater operating economies attainable in gridded areas.

- Bus mode share by place of work is related to the cost of parking, transit access to downtown, and overall density. Yet, all these factors together explain only a small part of the variation in bus mode shares by place of work. Perhaps additional variables need to be introduced or existing variables need to be re-specified; regional transit accessibility and density variables are candidates for re-specification. Or we may need to take an entirely different analytical tack; bus use could be modeled in terms of interzonal flows rather than zonal totals.

- Overall density is a significant determinant of bus mode share, though its effect is largely indirect (through auto ownership and parking charges). The relationship between density and mode share, when reduced to mathematical equations, allows us to compute required density for any level of transit productivity or farebox recovery.

- Jobs-housing balance has a positive but small effect on bus use by place of residence and no effect by place of work. Having a “perfect” balance of 1.5 jobs per household raises the bus mode share by 0.024 (two percentage points) relative to having either jobs or housing but not both. Another mixed-use variable, which captures the degree of mixing of residential, commercial, service, and industrial uses, has no effect or an adverse effect on bus use (depending on what other variables are tested at the same time). Either this mixed-use variable is misspecified

or our preconception about the positive effect of mixed uses on transit ridership is erroneous.

ENDNOTES

¹ H.S. Levinson and F.H. Wynn, "Effects of Density on Urban Transportation Requirements," *Highway Research Record* 2, 1963, pp. 38-64; A.M. Guest and C. Cluett, "Analysis of Transit Ridership Using 1970 Census Data," *Traffic Quarterly*, Vol. 30, 1976, pp. 143-161; D.T. Hunt et al., "A Geodemographic Model for Bus Service Planning and Marketing," *Transportation Research Record* 1051, 1986, pp. 1-12; R.J. Spillar and G.S. Rutherford, "The Effects of Population Density and Income on Per Capita Transit Ridership in Western American Cities," *ITE 1990 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, D.C., 1990, pp. 327-331; P.W.G. Newman and J.R. Kenworthy, *Cities and Automobile Dependence: A Sourcebook*, Gower Technical, Brookfield, VT, 1991, pp. 34-68; and R.T. Dunphy and K.M. Fisher, "Transportation, Congestion, and Density: New Insights," Paper presented at the 73rd Annual Meeting, Transportation Research Board, Washington, D.C., 1994.

² A.R. Tomazinis et al., *A Study on Factors Affecting Success of Suburban Mass Transit Lines*, Urban Mass Transportation Administration, Washington, D.C., 1979, pp. 59-85; R. Cervero, "Land Use and Travel at Suburban Activity Centers," *Transportation Quarterly*, Vol. 45, 1991, pp. 479-491; and Cambridge Systematics, Inc., *The Effects of Land Use and Travel Demand Management Strategies on Commuting Behavior*, Technology Sharing Program, U.S. Department of Transportation, Washington, D.C., 1994, pp. 3-5 through 3-10.

³ Cambridge Systematics, Inc., op. cit, pp. 3-19 through 3-21; and Parsons Brinckerhoff Quade Douglas, Inc., *The Pedestrian Environment - Volume 4A*, 1000 Friends of Oregon, Portland, OR, 1993, pp. 5-21.

⁴ R. Cervero, "Evidence on Travel Behavior in Transit-Supportive Residential Neighborhoods," *Transit-Supportive Development in the United States: Experiences and Prospects*, Technology Sharing Program, U.S. Department of Transportation, Washington, D.C., 1993, pp. 127-163; Sasaki Associates, Inc., *Transit and Pedestrian Oriented Neighborhoods*, Maryland-National Capital Park & Planning Commission, Silver Spring, MD, 1993, pp. 47-53; and B. Friedman, S.P. Gordon, and J.B. Peers, "Effect of

Neotraditional Neighborhood Design on Travel Characteristics," *Transportation Research Record* 1466, 1994, pp. 63-70.

⁵ K. Neels et al., *An Empirical Investigation of the Effects of Land Use on Urban Travel*, The Urban Institute, Washington, D.C., 1977, pp. 63-65.

⁶ L.D. Frank and G. Pivo, "Impacts of Mixed Use and Density on the Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, and Walking," *Transportation Research Record* 1466, 1994; and L.D. Frank and G. Pivo, *Relationships Between Land Use and Travel Behavior in the Puget Sound Region*, Washington State Department of Transportation, Seattle, WA, 1994, pp. 14-34.

⁷ The pedestrian environment factor or PED is the sum of scores for: ease of street crossings, sidewalk continuity, local street network type (grid vs. curvilinear), and topography. The national demonstration project is reported in Cambridge Systematics, *Model Modifications - Volume 4*, 1000 Friends of Oregon, Portland, 1992.

⁸ R. Cervero, "Rail-Oriented Office Development in California: How Successful?" *Transportation Quarterly*, Vol. 48, 1994, pp. 33-44.

⁹ R. Kitamura, P.L. Mokhtarian, and L. Laidet, "A Micro-Analysis of Land Use and Travel in Five Neighborhoods in the San Francisco Bay Area," Paper presented at the 74th Annual Meeting, Transportation Research Board, Washington, D.C., 1995.

¹⁰ A few researchers have tested automobile service variables as well, for example, the ratio of auto-to-transit travel times. Given our databases, such a variable would be very difficult to operationalize.

¹¹ For more on the subject of aggregation (and lost information), see E.I. Pas, "An Empirical Comparison of Zonal, Household, and Personal Models of Home-Based Trip Generation," *Traffic & Engineering Control*, Vol. 19, February 1978, pp. 64-68.

¹² Traffic analysis zones were dropped for three reasons: no walk access times or bus travel times were available for them; no bus routes ran through them, causing the logarithm of route density (the variable used in our analysis) to be undefined; or the internal road network was such a hybrid that it could not be rated on our 1 to 5 scale.

¹³ Frank and Pivo tested an entropy variable.

¹⁴ See any advanced econometrics textbook, e.g., B. Bacon, *A First Course in Econometric Theory*, Oxford University Press, London, 1988, pp. 247-277; and A.H. Studenmund, *Using Econometrics - A Practical Guide*, Harper Collins Publishers, New York, 1992, pp. 535-563.



Appendix C

Ridership Analysis — Urban Design Characteristics

Appendix B investigated the effects of land use patterns on transit mode shares. In Appendix C, the focus shifts to *urban design characteristics* and their effects on transit ridership.

Variables and units of analysis change between appendices. Appendix B explained mode shares of employees living or working within traffic analysis zones (TAZs), using TAZ characteristics as explanatory variables. This appendix explains *ridership at sampled bus stops* in terms of characteristics of the *service areas around the stops*.

Prior Studies

Urban design characteristics have received less attention in the transit-oriented development literature than have land use patterns, and studies relating transit ridership to urban design characteristics have been less conclusive.

Reaching one conclusion was a study relating rail's share of work trips to occupational, land use, and eight urban design characteristics. "...within walking distance of a rail station, the physical characteristics of the surrounding environment matter little in shaping commuting choices (ignoring issues of safety and urban blight)...."¹

Reaching an entirely different conclusion was a study of pedestrian and transit mode shares versus a composite measure, called a "pedestrian environment factor" or PEF. This PEF accounts for ease of street crossings, sidewalk continuity, street pattern (grid vs. cul-de-sac), and topography. The conclusion: "In general, there is an upward trend in the use of pedestrian and transit modes as the PEF increases, becoming particularly pronounced as the PEF value exceeds eight."²

Differences in study results may be due, in whole or part, to differences in study designs (between these two studies and others reviewed in Appendix B). Urban design characteristics may appear insignificant when tested individually, but quite significant when combined into an overall "pedestrian-friendliness" measure. Conversely, urban design characteristics may appear significant when they are tested alone, but insignificant when tested in combination with land use and transit service variables with which they are correlated.

We would like to understand how urban design variables collectively affect transit ridership, and how they interact with land use variables to compound effects on transit ridership.

Dependent Variable and Unit of Analysis

The change to ridership as our dependent variable, and to the individual bus stop as our unit of analysis, has both pluses and minuses. The big plus is that the areas under study are smaller and typically more homogeneous than TAZs. Making the standard assumption that bus stops draw riders from a 1/4-mile street distance around stops, the service area of a bus stop is 1/8 square mile in a gridiron street pattern. This compares with TAZs averaging almost 1/2 square mile outside downtown Miami, and ranging up to a several square miles in peripheral areas.

Transit service variables can be estimated with greater precision when individual stops are the units of analysis. There is no need to average and aggregate bus service characteristics across bus routes, as there is with TAZs.

Our dependent variable now accounts for all trips by bus, not just work trips. Work trips, the subject of Appendix B, constitute only a quarter of all trips in the U.S. and fewer than half of all transit trips. They are almost certainly subject to different influences than trips for other purposes, a point in favor of this analysis.

There are disadvantages as well to our new dependent variable and new unit of analysis. Only a small sample can be drawn, for all data must be pieced together for bus stop service areas. This, in combination with the use of bus stop ridership as the dependent variable, based on one count per stop, is certain to produce a large sampling error.

Setting Up for This Study

The study began with the acquisition of Section 15 check sheets, completed by the Metro-Dade Transit Agency for federal reporting purposes. Section 15 check sheets record various data for sampled stops along sampled routes, including the numbers of riders getting on and off and the time of arrival and departure.

Our original sample consisted of nearly 100% of the bus stops visited, 280 in all, during afternoon peak hours (4-6 pm) on weekdays of the peak season (October-April) of 1989-1990. The only stops not included in the sample were those visited when it was raining, a condition expected to depress ridership. The sample was drawn for this period, late 1989 and early 1990, to coincide with the 1990 U.S. Census of Population and Housing, our initial source of sociodemographic and land use data.

From the sample of bus stops originally chosen, a subsample was taken. Stops that function as transfer points—such as rail stations—were dropped because their ridership levels depend

less on the land use and urban design characteristics of their immediate surroundings than on the transit connections they afford. Stops in central and northern areas of Dade County were sampled in smaller proportions than those in western and southern areas, the latter being far less numerous in our original sample. For modeling purposes, we wanted the maximum possible variance in both dependent and independent variables, and a *stratified random sample* promised that. The final subsample consisted of 157 bus stops.

(1) Transit Variables

Section 15 check sheets, transit route maps, “assignment of equipment” forms, and outputs of Dade County’s regional travel model were used to create a database with the following variables:

RIDERSHIP = sum of boardings and deboardings at the sampled stop along the sampled route

This became our dependent variable.

PEAK-FREQ = peak hour service frequency on the sampled route

More frequent service will tend to attract more riders; however, the riders who are attracted will be split among more bus runs. *PEAK-FREQ* may have a positive relationship to transit ridership on the sampled bus trip, a negative relationship, or no relationship.

RUN-SPEED = scheduled run speed on the sampled route

There is some recent evidence that transit ridership is higher where interzonal travel times by transit are shorter. There is also evidence that transit draws better where traffic congestion is more severe, making the automobile less attractive as a travel mode. *RUN-SPEED* was included to test for such effects.

PARALLEL-ROUTES = number of parallel bus routes serving the sampled stop

This variable was included to account for competition among bus routes serving the same basic travel corridor.

CROSS-ROUTES = number of bus routes on cross streets at the sampled stop

This variable was included to account for bus transfer opportunities.

BUS-TIME = peak-hour run time by bus from the sampled stop to downtown Miami (in minutes)

This variable came from Dade County’s regional travel model (from the travel time “skins” generated by the model). Taken as representative of each stop was the TAZ whose centroid connected to the regional road network at a point closest to the stop. This variable was the best available proxy for regional transit accessibility (that is, accessibility to activities region-wide via transit). It serves as a decent proxy

thanks to the downtown orientation of Miami's bus system.

(2) Urban Design/Street Network Variables

For all bus stops in our final sample, urban design characteristics of service areas were estimated from aerial photographs. We were lucky to find a set of old aerials for the period under study (1989-1990).

A diamond-shaped overlay was used to delineate an area 1/4-mile street distance from each stop. The overlay took in exactly 1/4-mile in the case of gridded streets, and approximately 1/4-mile for other street patterns.

For consistency, the same two people measured all urban design characteristics. Independent visual inspection was followed by a con-

sensus-forcing discussion to arrive at common values. As far as we know, this is the first time that urban design variables have been estimated in this manner. It is quite time-consuming, requiring 15-20 minutes per stop when service areas lie entirely on one aerial, and much longer when they are divided between two or more aerials.

The result was a set of nine urban design/street network variables, with values for each bus stop. Reasons for choosing these particular variables are given in the body of this manual. All variables measure, in some way, the pedestrian-friendliness (or unfriendliness) of an area.

DEVELOPED = proportion of land developed

This variable treats all trip generating land, whether high rise or golf course, as developed.

Only areas generating no trips at all—water bodies, natural areas, and vacant lots—were considered undeveloped.

DEAD-FRONT = proportion of street frontage without buildings

This variable distinguishes between fronting uses that generate street activity and project a human presence, by virtue of doors and windows on the street, and those that do not. Large parking lots between the street and buildings were treated as dead spaces.

INTERSECTIONS = number of street intersections

This variable reflects the density of the street network and the length of blocks. More intersections are better for pedestrians, but not necessarily for motorists.

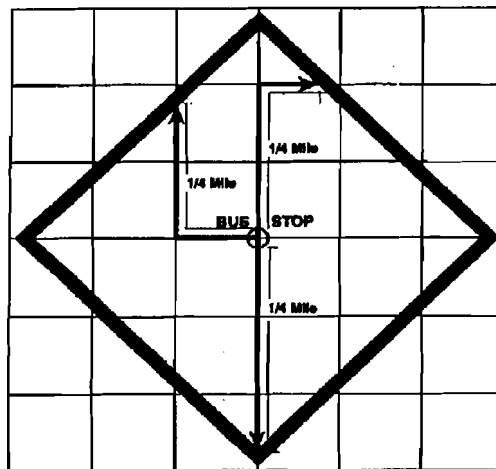
DEAD-ENDS = number of dead-end streets/cul-de-sacs

This variable reflects the degree of connectivity within the street network. More dead-ends translate into less direct pedestrian access routes.

GRID = 1 for pure grid or grid-like networks, 0 otherwise

This dummy variable assumes a value of 1 for networks rated 1 or 2 on the scale described in Appendix B, and 0 for other networks. Grid

Area within 1/4-Mile Street Distance of a Bus Stop



or grid-like networks provide multiple access routes to bus stops.

NONGRID = 1 for highly discontinuous networks, 0 otherwise

This dummy variable assumes a value of 1 for networks rated 4 or 5 on the scale described in Appendix B, and 0 for other networks.

SIDEWALKS = proportion of street frontage with sidewalks

TREES = proportion of street frontage with trees

CROSSWALKS = number of striped crosswalks

(3) Sociodemographic/Land Use Variables

Initially, it was thought that the sociodemographic and land use characteristics of areas around bus stops could be adequately represented by TAZ data used in Dade County's regional travel model. These are the same characteristics tested for relationships to transit market shares in Appendix B. Here, however, the unit of analysis is the bus stop, not the TAZ.

For all sampled bus stops, it was determined which TAZs fall within the service areas around the stops. Up to six TAZs, those most proximate to stops, were recorded for each stop. To be included, a TAZ had to have at least 20% of its land area within a quarter mile of the stop. The 20% requirement was violated only in outlying areas, where TAZs are so large we simply took

the TAZ with the most land within the bus stop service area.

With proximate TAZs known for each stop, values of sociodemographic and land use variables could be computed. The variables are the same as in Appendix B, but for the fact that values were usually averaged over several zones.

0/1-AUTOS = proportion of households owning 0 or 1 vehicles

INCOME = median household income in thousands, where midpoints of income ranges are used in the absence of actual median values

MULTIFAMILY = proportion of multifamily housing units in the local housing stock

LOG-OVERDEN = \log_{10} [(total population + total employment)/land area in square miles]

As in Appendix B, the use of overall density is dictated by data limitations. We could not compute net densities because only total land areas of zones were known (not areas devoted to different land uses). We took the logarithm of overall density to reduce the skewing effect of "outliers," that is, data points well beyond the normal density range, mainly downtown zones with extremely high employment densities.

BAL-MIX-1 = $1 - [Absolute\ Value\ (total\ employment - 1.5 \times total\ housing\ units) / (total\ employment + 1.5 \times total\ housing\ units)]$

This mixed-use variable ranges from 0 to 1, depending on the degree of jobs-housing balance. It assumes a value of 1 when jobs and housing units are in nominal balance and 0 when only jobs or housing units are present within the service area, not both. A nominal balance is taken as 1.5 jobs per housing unit.

DEGREE-MIX-1 = $\{[housing\ units \times \log_{10}(housing\ units)] + [retail\ jobs \times \log_{10}(retail\ jobs)] + [service\ jobs \times \log_{10}(service\ jobs)] + [industrial\ jobs \times \log_{10}(industrial\ jobs)]\} / (housing\ units + retail\ jobs + service\ jobs + industrial\ jobs)$

This mixed-use variable is an adaptation of an "entropy" variable tested in earlier land use/travel studies. Holding the total activity level constant, this variable will assume a higher value where there is less land-use mixing, a lower value where there is more.

COMM-SERV = proportion of local jobs in commercial and service sectors for proximate TAZs

This variable accounts for differences in transit trip generation between commercial/service and industrial sectors.

Initial Results

Having constructed a database for 157 sampled bus stops, we were able to run multiple regression analyses with *RIDERSHIP* as the dependent variable and the 21 characteristics defined above as the independent variables.

Results of our "best" initial run were:

$$\begin{aligned} \text{RIDERSHIP} = & - 1.2 + 0.52 \times \text{CROSS-ROUTES} + \\ & (2.9) \\ & 0.23 \times \text{CROSSWALKS} + 4.3 \times \text{DEAD-FRONT} \\ & (3.2) \quad (2.7) \\ R^2 = & 0.17 \end{aligned}$$

where the values in parentheses are the t-statistics of the regression coefficients. All regression coefficients are significant at the 0.01 level or beyond.

In some respects, this is not a bad regression equation. While the independent variables together account for only 17% of the variation in ridership among sampled bus stops, this is to be expected, given the random nature of boardings and deboardings at individual stops on individual bus trips. Two of three explanatory variables enter with the expected signs at significant levels, and the third sign can be explained away. Intuitively, bus stop ridership should increase with the number of cross routes, each representing bus transfer opportunities. Ridership should also increase with the number of crosswalks within the 1/4-mile service area, crosswalks making it easier to gain access to bus stops.

As for dead-street frontage, ridership would be expected to decrease, not increase, with the proportion of dead-street frontage within the service area. This is a spurious correlation resulting from the high proportion of street frontage devoted to parking within major employment centers (see below).

Yet, even with this anomaly explained, the estimated regression equation is not particularly satisfactory. The urban design variables expected to be most significant, such as the proportion of street frontage with sidewalks (*SIDEWALKS*) and the number of intersections (*INTERSECTIONS*) within the service area, are missing from the equation. More important, all sociodemographic or land use variables for the TAZs around stops are missing. Even auto ownership (*O/I-AUTOS*) and urban density (*LOG-OVERDEN*) failed to enter at significant levels.

Now, we know that transit ridership is heavily influenced by auto ownership, density, and other such variables. And we can be reasonably sure that crosswalks by themselves do not induce people to use transit.

Regarding the failure of sociodemographic and land use variables to enter, the only plausible explanation is that characteristics of transit service areas cannot be adequately represented by data for TAZs or any other geographic units unrelated to transit stops. This calls into question standard transit planning procedures, which make use of data for TAZs, census tracts, or census block groups. Finer geographic detail would appear to be required, the kind of detail available from *geographic information systems*.

Regarding the overriding importance of crosswalks and dead-street frontage, we must assume such variables serve as proxies for other factors, as yet unmeasured, that determine the

walkability and transit potential of transit service areas. It is these underlying factors we wish to measure, and the obvious way to measure them is with *factor analysis*.

Second Attempt

With this in mind, Dade County was asked to provide land use data for the service areas around sampled bus stops. Because the product of our research was potentially useful to the Metro-Dade Transit Agency, the agency acted as our "client" inside county government.

Parcel-level data were requested from the county's geographic information system (GIS). The data of interest for each parcel were: the county land use code; number of housing units located within the parcel; floor area of all buildings within the parcel; and land area of the parcel.

Dade County's GIS was programmed to select parcels lying at least partly within the 1/4-mile diamond-shaped areas around sampled bus stops (as in the figure above). Sampled bus stops were geocoded, parcels within the defined areas were selected, and data for parcels so selected were written into a separate file for each bus stop. At the same time, the county's detailed land use codes were translated into simple land use classes corresponding to those used in regional travel modeling, that is, single-family, multifamily, hotel-motel, commercial, service, and industrial uses. Among the additional codes

defined by the county and combined into a separate class were mixed land use codes.

A summary file was then produced for each bus stop that summed the housing units, building floor areas, and land areas of all parcels within the 1/4-mile service area. These summary files were ultimately joined with one another, and the resulting file was merged with our base file to obtain a new working file of transit, urban design, and land use data for all 157 bus stops.

(1) New Land Use Variables

Using GIS data, the following variables were derived for bus stop service areas:

POPULATION = number of residents living within the 1/4-mile service area

Residential population was estimated assuming 3.2 persons per single-family unit, 2.3 per multifamily unit, and 1.6 per hotel-motel unit.

EMPLOYMENT = number of employees working within the service area

Total employment was estimated assuming 2 jobs per 1,000 square feet gross floor area (GFA) for industrial uses; 3 jobs per 1,000 square feet GFA for service uses; and 4 jobs per 1,000 square feet GFA for commercial and mixed uses.

BAL-MIX-2 = same as *BAL-MIX-1* but computed with housing unit counts and total employment estimates for bus stop service areas

DEGREE-MIX-2 = same as *DEGREE-MIX-1* but computed with housing unit counts and sector employment estimates for bus stop service areas

COMM-SERV-MIX = estimated proportion of jobs in commercial, service, or mixed use sectors within bus stop service areas

(2) Missing Variables

Missing from this set of variables are *average net residential density* and *average commercial floor area ratio* (FAR). We had planned to test both variables, and expected both to be significant. This was to have been one of those rare instances when land areas are known for individual land uses, and hence net rather than gross densities can be calculated.

The problem came when net densities and FARs computed with GIS data fell, in many cases, far outside the normal range of values for particular land uses. Upon inspection, it became clear that land area data from the County's GIS could not be trusted. These data had to be discarded. A request has been made to Dade County for parcel area data from another layer of the County's GIS. Should the resulting data prove reliable, we will repeat the analysis including these two additional variables.

(3) Better Results

Ridership at sampled bus stops was regressed on transit service, urban design, and the new land use variables. Only two variables entered the regression equation at the 0.05 significance level, *CROSS-ROUTES* and *EMPLOYMENT*. While the explanatory power of the equation is very limited, at least the "right" variables entered with the "right" signs.

This result has important, but subtle, implications for transit-oriented development. Ridership (the sum of ons and offs) is more closely related to employment within bus stop service areas than it is to resident population. This tends to confirm a tenet of the transit-oriented development literature—that *employment concentrations generate more transit trips than do residential concentrations*.³ At the residential end, it is not so much the density of population that counts as the socioeconomics of the population. High transit mode shares are a product of low auto ownership rates, and low auto ownership rates are a product mainly of low household incomes (see Appendix B).

Like resident population, *all other land use and urban design variables proved insignificant*. This does not mean that all other variables are irrelevant to transit ridership, only that they are not significant independently of employment levels. The next section explores their relationship to employment levels and, ultimately, to transit ridership.

Factor Analysis

Knowing that land use and urban design characteristics go hand-in-hand, a decision was made to treat them as interdependent rather than independent variables. When variables are highly correlated, factor analysis can be used to identify a small number of "underlying" factors capable of representing relationships among a large number of "observable" variables. In factor analysis, the original variables are expressed as linear combinations of the factors they have in common. These factors are more fundamental in some sense than the variables one can measure. Readers are referred to any text on multivariate statistics for more information about factor analysis.

Starting with *nine* urban design variables and *five* land use variables, we extracted three factors (principal components) together capable of explaining more than half of the combined variance of the 14 variables. These principal components were rotated to obtain factors that loaded heavily on certain variables, and not so heavily on others; rotation is helpful when it comes time to interpret the underlying factors.

From relationships between the original variables and underlying factors, "factor scores" were computed for each factor at each bus stop. The result was a set of three new variables, our rotated factors, that could

be used in subsequent analyses in place of the original variables.

Based on their factor loadings, the first and third factors seem to embody different aspects of "pedestrian-friendliness." Both are positively related to crosswalks, active street-level uses (a minimum of dead frontage), gridded streets, and at least a modicum of balance between jobs and housing. In addition, *FACTOR 1* is closely related to the proportion of developed land and number of intersections within bus stop service areas, while *FACTOR 3* is closely related to the proportion of street front-

age with sidewalks and the resident population of service areas.

FACTOR 2 is very different from the other two factors. It loads heavily on the number of employees within bus stop service areas. It also loads heavily on the two variables representing the mix of land uses, but here its relationship is inverse. More balanced and varied mixes are associated with *lower* factor scores. (Recall that *DEGREE-MIX* is defined such that its value decreases as the degree of mixing increases.) The only pedestrian-friendly features to which *FACTOR 2* relates are the

Rotated Factor Loadings (Varimax Rotation)

	FACTOR 1	FACTOR 2	FACTOR 3
DEVELOPED	0.64	0.01	-0.20
DEAD-FRONT	-0.49	0.21	-0.45
SIDEWALKS	0.18	0.25	0.56
TREES	-0.38	-0.05	0.02
CROSSWALKS	0.58	0.23	0.47
INTERSECTIONS	0.75	-0.09	0.27
DEAD-ENDS	-0.43	-0.10	0.61
GRID	0.55	0.11	0.27
NONGRID	-0.44	-0.08	-0.06
POPULATION	-0.07	-0.04	0.76
EMPLOYMENT	0.27	0.82	0.17
BAL-MIX-2	0.14	-0.80	0.18
DEGREE-MIX-2	0.12	0.87	0.31
COMM-SERV-MIX	0.09	0.12	0.49

proportion of street frontage with sidewalks and the number of crosswalks within the service area.

By plotting factor scores of sampled bus stops on a county map, the “meaning” of the factors became clear. They represent area prototypes. Areas with high scores on *FACTOR 1* are mostly older urban neighborhoods of single-family houses internal to blocks and apartments, shops, and scattered houses fronting on major streets. The first pair of photos below, of a bus stop service area in Little Havana, is typical of these areas.

Areas scoring high on *FACTOR 2* are, with one or two exceptions, in the downtown business district. These are employment centers with many jobs and few, if any, residents. The second pair of photos, of a downtown service area, typifies these areas.

Areas scoring high on *FACTOR 3* are mostly neighborhoods near the water with mid-rise apartments and shops and hotels along the main streets. The inverse relationship to developed land and the direct relationship to dead-end streets is due to the 1/4-mile “service area” extending out into the ocean or intercoastal waterway. The third pair of photos, of a service area in Miami Beach, is typical of these areas.

Final Results

Using the three composite factors and transit service variables as our independent variables, a final ridership model was estimated with regression analysis. The best fit was achieved with:

$$\begin{aligned} \text{RIDERSHIP} = & 2.5 + 0.64 \times \text{CROSS-ROUTES} + \\ & (3.6) \\ & 0.73 \times \text{FACTOR 2} \\ & (2.0) \\ R^2 = & 0.13 \end{aligned}$$

where the values in parentheses are the *t*-statistics of the regression coefficients. *CROSS-ROUTES* is significant at the 0.001 level, *FACTOR 2* at the 0.05 level.

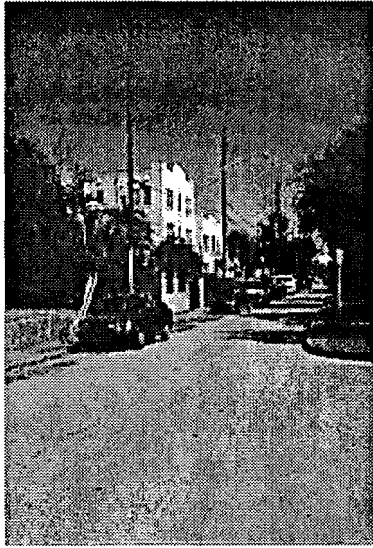
Both variables enter with the expected signs at significant levels. While disappointing, the low R^2 is not cause for too much concern, given the nature of the dependent variable, ridership at an individual stop on a single bus trip. That *FACTOR 2* entered, and *FACTORS 1 and 3* did not even come close to entering, has implications for transit-oriented development. Basically, if employment is concentrated around bus stops, it is only necessary that there be decent sidewalk continuity and occasional crosswalks in order to ensure a moderate level of transit use.

What We Learned

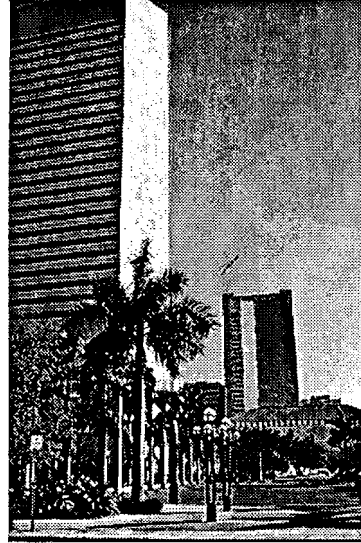
This study is, admittedly, exploratory. Its value lies more in the methodological ground it breaks than its substantive conclusions about urban design influences on transit ridership. Regarding methodology:

- Section 15 data represent an untapped source of transit ridership information, but one that is difficult to tap due to the random nature of boardings and deboardings at individual bus stops. It is possible to compensate for this random element by taking a large sample of bus stops. But then one must measure land use and urban design characteristics for a large number of bus stops, a very labor-intensive exercise.
- Aerial photos can be used to measure urban design characteristics of transit service areas. Aerials are available everywhere and easy to work with. They can be “read” with confidence as long as the physical features of interest are at the scale of individual buildings or street sections. Even the presence of sidewalks, crosswalks, and individual trees can be established with a high degree of reliability, as we confirmed with a windshield survey of a bus stop service area previously analyzed with an aerial photo.
- Data for TAZs, census tracts, or census block groups have limited applicability to transit ridership analysis since the boundaries of such areas seldom (if ever) coincide with the service areas of transit stops and stations. The obvious

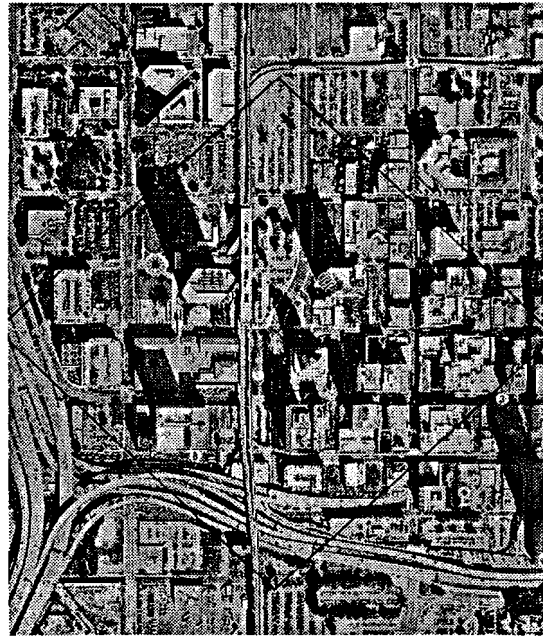
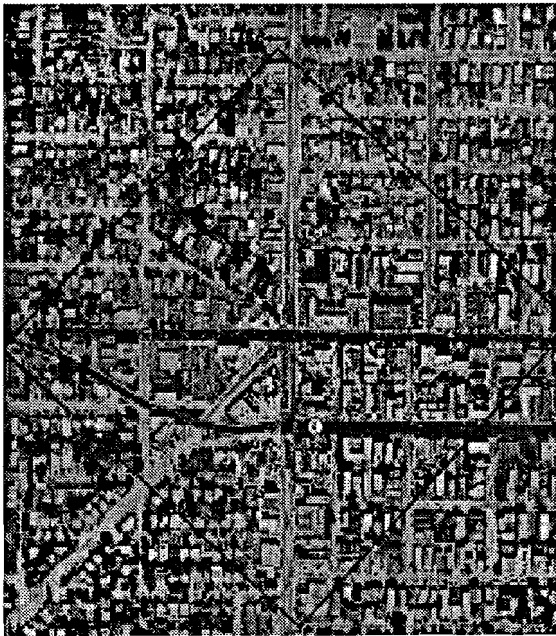
Little Havana Service Area Scoring High on FACTOR 1



Downtown Service Area Scoring High on FACTOR 2



Miami Beach Service Area Scoring High on FACTOR 3



alternative, extracting parcel-level data from geographic information systems and then aggregating, may not be the panacea it at first appears. In this particular application, reliance on GIS databases resulted in long delays and heavy post-processing demands, and even then, some data were of such poor quality that key land use variables could not be estimated.

As for substantive conclusions, it appears that:

- The most important determinants of ridership at individual bus stops are the number of cross routes affording transfer opportunities, and the number of workers employed within the immediate area. The importance of nearby employment tends to confirm a tenet of the transit-oriented development literature—that employment concentrations generate more transit trips than do residential concentrations.
- Urban design variables have little, if any, independent effect on transit ridership after controlling for land use and transit service variables. If design variables have an effect, it is through interactions with land use and transit service variables, enhancing in some cases and detracting in others. A serious exploration of interactive effects must await a larger database.
- Our attempt to capture interrelationships among land use and design variables through factor analysis, and then model transit ridership

in terms of underlying factors, proved moderately successful. Areas generating large numbers of transit trips have, in addition to lots of jobs nearby, better than average sidewalk continuity and more than average numbers of crosswalks. These two urban design characteristics, which facilitate transit access, may be necessary to convert potential transit users at nearby work sites into actual transit users.

- *Transit-friendly development is not the same as pedestrian-friendly design.* From our factor analysis, the two factors that capture most aspects of pedestrian-friendliness have no relation to transit ridership, while the one factor that captures few aspects of pedestrian-friendliness has a significant relationship. By way of illustration, high amenity neighborhoods along Miami Beach generate relatively few transit trips, while the stark downtown office district generates many transit trips.

ENDNOTES

¹ R. Cervero, "Rail-Oriented Office Development in California: How Successful?" *Transportation Quarterly*, Vol. 48, 1994, pp. 33-44.

² Parsons Brinckerhoff Quade Douglas, Inc., *The Pedestrian Environment - Volume 4A*, 1000 Friends of Oregon, Portland, OR, 1993, p. 18.

³ Section 15 counts were taken during the afternoon peak period (4-6 pm) when riders would have been boarding buses at work and deboarding at home. Across the entire sample, about the same number of riders got on and off during this period. Thus, the fact that employment numbers proved more important than population numbers is not an artifact of our sampling strategy.



F2 Source: A.B. Jacobs, *Great Streets*, MIT Press, Cambridge, Mass., 1993, p. 249.

F3 Source: A.B. Jacobs, *Great Streets*, MIT Press, Cambridge, Mass., 1993, p. 225.

F4 Source: A.B. Jacobs, *Great Streets*, MIT Press, Cambridge, Mass., 1993, p. 221.

F5 Source: Governor's Task Force on Urban Growth Patterns, *Final Report*, Florida Department of Community Affairs, Tallahassee, 1989, p. 8.

F6 USE F6-1 NOT F-6!!!!

F6-1 Source: Household Travel Survey, Palm Beach County, 5/91-7/91.

F7 Source: Household Travel Survey, Palm Beach County, 5/91-7/91.

F8 Source: R. Ewing, "Beyond Density, Mode Choice, and Single-Purpose Trips," *Transportation Quarterly*, Vol. 49, 1995, pp. 15-24.

F9 Source: W. Kulash, "Neotraditional Town Design — Will the Traffic Work?" Session Notes - AICP Workshop on Neotraditional Town Planning, American Institute of Certified Planners, Washington, D.C., 1991.

F10 Source: S.A. Smith, *Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas*, National Cooperative Highway Research Program Report 294A, Transportation Research Board, Washington, D.C., 1987, p. 62.

F11 Source: R.L. Knoblauch et al., *Investigation of Exposure Based Pedestrian Accident Areas: Crosswalks, Sidewalks, Local Streets and Major Arterials*, Federal Highway Administration, Washington, D.C., 1988, p. 54.

F12 Source: G.K. Neilson and W.K. Fowler, "Relation Between Transit Ridership and Walking Distances in a Low-Density Florida Retirement Area," *Highway Research Record* 403, 1972, pp.

F13 Source: Adapted from American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1990, p. 197.

F14 Source: American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1990, p. 47.

F15 Source: Rendering by Oscar Vagi and Associates, *TMA Express: News from the Downtown Fort Lauderdale Transportation Management Association*, Spring, 1995, p. 1.

F16 Source: Rhodeside & Harwell, Inc. and Keyes Condon Florance - Architects, *Installation Design Guide - Fort Belvoir, Virginia*, 1988, p. III 3.4-2.

F17 Source: Rhodeside & Harwell, Inc. and Keyes Condon Florance - Architects, *Installation Design Guide - Fort Belvoir, Virginia*, 1988, p. III 5.2-12.

F18 Source: Rhodeside & Harwell, Inc. and Keyes Condon Florance - Architects, *Installation Design Guide - Fort Belvoir, Virginia*, 1988, p. III 5.5-2.

F21 Source: E. Beimborn and H. Rabinowitz, *Guidelines for Transit Sensitive Land Use Design*, Technology Sharing Program, U.S. Department of Transportation, Washington, D.C., 1991, p. 112.

F22 Source: E. Beimborn and H. Rabinowitz, *Guidelines for Transit Sensitive Land Use Design*, Technology Sharing Program, U.S. Department of Transportation, Washington, D.C., 1991, p. 114.

F26 Source: H. Arnold, *Trees in Urban Design*, Van Nostrand Reinhold, New York, 1993, p. 54.

F27 Source: H. Arnold, *Trees in Urban Design*, Van Nostrand Reinhold, New York, 1993, p. 55.

F28 Source: H. Arnold, *Trees in Urban Design*, Van Nostrand Reinhold, New York, 1993, p. 55.

F29 Source: H. Arnold, *Trees in Urban Design*, Van Nostrand Reinhold, New York, 1993, p. 58.

F30 Source: H. Arnold, *Trees in Urban Design*, Van Nostrand Reinhold, New York, 1993, p. 73.

F31 Source: D.T. Smith and D. Appleyard, "Studies of Speed and Volume on Residential Streets," *Improving the Residential Street Environment*, Federal Highway Administration, Washington, D.C., 1981, pp. 127.

F32 Source: Glatting Jackson Kercher Anglin Lopez Rinchart, Inc., *Central Florida Mobility Design Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 7-4.

F33 Source: Glatting Jackson Kercher Anglin Lopez Rinchart, Inc., *Central Florida Mobility Design Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 2-6.

F34 Source: Herbert - Halback, Inc., *Lynx - Customer Amenities Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 5.3.

F35 Source: Herbert - Halback, Inc., *Lynx - Customer Amenities Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 5.11.

F36 Source: Herbert - Halback, Inc., *Lynx - Customer Amenities Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 5.5.

F37 Source: Herbert - Halback, Inc., *Lynx - Customer Amenities Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 4.8.

F39 Source: Glatting Jackson Kercher Anglin Lopez Rinchart, Inc., *Central Florida Mobility Design Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 6-7.

F40 Source: Herbert - Halback, Inc., *Lynx - Customer Amenities Manual*, Central Florida Regional Transportation Authority, Orlando, 1994, p. 1.4.

F41 Source: Maryland Department of Transportation and Mass Transit Administration, *Access by Design: Transit's Role in Land Development - A Developer's Manual*, 1988, p. 55.

F42 Source: Maryland Department of Transportation and Mass

Transit Administration, *Access by Design: Transit's Role in Land Development - A Developer's Manual*, 1988, p. 57.

F44 Source: Maryland Department of Transportation and Mass Transit Administration, *Access by Design: Transit's Role in Land Development - A Developer's Manual*, 1988, p. 61.

F45 Source: Denver Regional Council of Governments, *Suburban Mobility Design Manual*, Denver, CO, 1993, p. 29.

F46 Source: Denver Regional Council of Governments, *Suburban Mobility Design Manual*, Denver, CO, 1993, p. 29.

F47 Source: Denver Regional Council of Governments, *Suburban Mobility Design Manual*, Denver, CO, 1993, p. 12.

F48 Source: Denver Regional Council of Governments, *Suburban Mobility Design Manual*, Denver, CO, 1993, p. 11.

F49 Source: W. Bowes, M. Gravel, and G. Noxon, *Guide to Transit Considerations in the Subdivision Design and Approval Process*, Transportation Association of Canada, Ottawa, Ontario, 1991, p. A-8.

F50 Source: Ontario Ministry of Transportation, *Transit-Supportive Land Use Planning Guidelines*, Toronto, 1992, p. 18.

F51 Source: P. Calthorpe, *The Next American Metropolis - Ecology, Community, and the American Dream*, Princeton Architectural Press, New York, 1993, p. 111.

F52 Source: P. Calthorpe, *The Next American Metropolis - Ecology, Community, and the American Dream*, Princeton Architectural Press, New York, 1993, p. 111.

F53 Source: P. Calthorpe, *The Next American Metropolis - Ecology, Community, and the American Dream*, Princeton Architectural Press, New York, 1993, p. ?.

F54 Source: P. Calthorpe, *The Next American Metropolis - Ecology, Community, and the American Dream*, Princeton Architectural Press, New York, 1993, p. ?.

F55 Source: P. Calthorpe, *The Next American Metropolis - Ecology, Community, and the American Dream*, Princeton Architectural Press, New York, 1993, p. ?.

ural Press, New York, 1993, p. ?.

F56 Source: Calthorpe Associates, *Transit-Oriented Development Design Guidelines*, Sacramento County, Calif., 1990, p. 68.

F57 Source: Calthorpe Associates, *Transit-Oriented Development Design Guidelines*, Sacramento County, Calif., 1990, p. 68.

F58 Source: Calthorpe Associates, *Transit-Oriented Development Design Guidelines*, Sacramento County, Calif., 1990, p. 41.

F59 Source: Edward D. Stone, Jr and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 2.2.

F60 Source: Edward D. Stone, Jr and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 3.3.

F61 Source: Edward D. Stone, Jr and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 3.5.

F63 Source: Edward D. Stone, Jr and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 3.16.

F68 Source: Edward D. Stone, Jr and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 3.30.

F69 Source: Edward D. Stone, Jr and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 3.21.

F70 Source: Edward D. Stone, Jr and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 3.40.

F71 Source: Edward D. Stone, Jr and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 3.40.

F74 Source: Edward D. Stone, Jr and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 4.4.

F75 Source: Edward D. Stone, Jr and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 4.26.

F76 Source: Edward D. Stone, Jr and Associates, *Riverwalk Design*

Guidelines, City of Fort Lauderdale, Fla., 1986, p. 4.2.

F77 Source: Edward D. Stone, Jr and Associates, *Riverwalk Design Guidelines*, City of Fort Lauderdale, Fla., 1986, p. 4.23.

F78 Source: Bucks County Planning Commission, *Village Planning Handbook*, Doylestown, Pa., undated, p. 34.

F79 Source: City of Bellevue, Wash., *Design Guidelines - Building/Sidewalk Relationships*, 1983, p. 14.

F80 Source: City of San Bernardino, Calif., *Title 19 - City of San Bernardino Municipal Code*, 1991, p. 11-40.

F81 Source: City of San Bernardino, Calif., *Title 19 - City of San Bernardino Municipal Code*, 1991, p. 11-47.

F82 Source: City of San Bernardino, Calif., *Title 19 - City of San Bernardino Municipal Code*, 1991, p. 11-120.

F84 Source: City of San Bernardino, Calif., *Title 19 - City of San Bernardino Municipal Code*, 1991, p. 11-145.

F85 Source: City of San Bernardino, Calif., *Title 19 - City of San Bernardino Municipal Code*, 1991, p. 11-133.

F86 Source: City of San Bernardino, Calif., *Title 19 - City of San Bernardino Municipal Code*, 1991, p. 11-133.

F87 Source: M.L. Hinshaw and Hough Beck & Baird, Inc., *Design Objectives Plan: Entryway Corridors - Bozeman, Montana*, 1992, p. 22.

F88 Source: M.L. Hinshaw and Hough Beck & Baird, Inc., *Design Objectives Plan: Entryway Corridors - Bozeman, Montana*, 1992, p. 42.

F89 Source: M.L. Hinshaw and Hough Beck & Baird, Inc., *Design Objectives Plan: Entryway Corridors - Bozeman, Montana*, 1992, p. 43.

F90 Source: J.B. Goldsteen and C.D. Elliott, *Designing America: Creating Urban Identity*, Van Nostrand Reinhold, New York, 1994,

p. 171.

F90 Source: J.B. Goldstein and C.D. Elliott, *Designing America: Creating Urban Identity*, Van Nostrand Reinhold, New York, 1994, p. 171.

F93 Source: R. Trancik, *Hamlets of the Adirondacks: A Manual of Development Strategies*, 1985, p. 95.

F94 Source: R. Trancik, *Hamlets of the Adirondacks: A Manual of Development Strategies*, 1985, p. 93.

F95 Source: R. Trancik, *Hamlets of the Adirondacks: A Manual of Development Strategies*, 1985, p. 92.

F96 Source: T. Barker and A. Bell, *Mid-City Design Plan*, City of San Diego, Calif., 1984, p. 25.

F97 Source: City of Toronto, *Urban Design Guidebook - Draft for Discussion*, 1995, p. 76.

F98 Source: City of Toronto, *Urban Design Guidebook - Draft for Discussion*, 1995, p. 55.

F99 Source: City of Toronto, *Urban Design Guidebook - Draft for Discussion*, 1995, p. 39.

F100 Source: City of Toronto, *Urban Design Guidebook - Draft for Discussion*, 1995, p. 31.

F101 Source: City of Toronto, *Urban Design Guidebook - Draft for Discussion*, 1995, p. 25.

F102 Source: City of Toronto, *Urban Design Guidebook - Draft for Discussion*, 1995, p. 25.

F103 Source: City and County of San Francisco, *Mission Bay Plan - Proposal for Adoption*, 1990.

F105 Source: R. Trancik, *Finding Lost Space—Theories of Urban Design*, Van Nostrand Reinhold, New York, 1986, p. 80.

F107 Source: City of Orlando, Fla., *Downtown Orlando Streetscape Design Guidelines*, 1988.

F108 Source: City of Orlando, Fla., *Downtown Orlando Streetscape Design Guidelines*, 1988.

F109 Source: K. Easterling, *American Town Plans: A Comparative Time Line*, Princeton Architectural Press, Princeton, N.J., 1993, p. 92.

F111 Source: A. Achimore, "Putting the Community Back into Community Retail," *Urban Land*, Vol. 52, August 1993, pp. 33-38.

F112 Source: P.N. Seneviratne, "Acceptable Walking Distances in Central Areas," *Journal of Transportation Engineering*, Vol. 3, 1985, pp. 365-????.





