SECTION

ANNOTATIONS OF STUDIES

This section contains detailed information on specific source materials of the literature on sprawl. The information is presented according to five basic categories (and their subcategories) of sprawl's impacts. A listing of works included here by author follows the references section of this monograph.

I. *Public and Private Capital and Operating Costs*
   1. Alternative Development Analyses
   2. Fiscal Impacts, Exactions, and Impact Fees
   3. The Effects of Growth Controls on Housing Costs
   4. Urban Form and Sprawl

II. *Transportation and Travel Costs*
   1. Changes in Automobile Travel
   2. The Effects of Density on Travel Choice
   3. Unlimited Outward Extension
   4. Spatial Segregation of Uses (Land Use Mix and Urban Design)
   5. Dispersed Employment
   6. The Costs of Travel

III. *Land/Natural Habitat Preservation*
   1. Land Preservation and Community Cohesion
   2. Land/Habitat Preservation: Empirical Studies

IV. *Quality of Life*
   1. Popular Literature
   2. Indicators, Report Cards, and Benchmarks
   3. Economics Literature
   4. Sociology Literature
   5. Psychology Literature

V. *Social Issues*
   1. The Growth of Cities and Metropolitan Areas
   2. Urban Decline
   3. Urban Renewal

The citations that have been annotated here are far from an exhaustive coverage of the individual topic. Yet, within the five basic categories of sprawl's impacts, there is a representation of some of the field's most important current and historical literature. Approximately 25 percent of the references have been annotated. Each of the annotated works is reviewed in a similar manner. The first portion of the analysis places the work in an overall context. A second component involves a discussion of why the work is important to the sprawl literature. A third component discusses methodology and data sources employed, if appropriate. A final component discusses results and conclusions of the work.

The annotations have been chosen to include both positive and negative positions on sprawl as well as a balance between descriptive and empirical works.

The annotations included here contribute to the judgments on strengths and weaknesses of the literature contained in the previous chapter. Sprawl has a rich and diverse literature, as will be seen in this compilation of annotations.

CHAPTER

9

Annotations of Studies

PUBLIC/PRIVATE CAPITAL AND OPERATING COSTS

This chapter annotates studies that relate to sprawl and the alleged *public/private capital and operating costs* that it imposes. *Public* capital and operating costs are costs associated with residential and nonresidential development: roads, utilities, public buildings and the costs of providing day-to-day police, fire, general government, recreational, and educational services. *Private* capital and operating costs are the expenses incurred in occupying residential and nonresidential properties—in other words, the costs imposed on housing and commercial development related to type, location, and density of development. The chapter is divided into four parts:

Alternative Development Analyses
Fiscal Impacts, Exactions, and Impact Fees
The Effects of Growth Controls on Housing Costs
Urban Form and Sprawl

The *Alternative Development Analyses* section includes the works of Robert W. Burchell (1997b, 1992a, and others), James Frank (1989), James Duncan (1989), RERC (1974), and Paul Tischler (1994), among others. *Fiscal Impacts, Exactions, and Impact Fees* includes, in addition to the above, the works of the American Farmland Trust (1986, 1992) and DuPage County, Illinois (1989, 1991). The *Effects of Growth on Housing Costs* literature includes the works of Katz and Rosen (1987), George Parsons (1992), and Seymour Schwartz et al. (1981 and 1989). Finally, the section on *Urban Form and Sprawl* includes the articles of Helen Ladd (1991) and Richard Peiser (1989).

ALTERNATIVE DEVELOPMENT ANALYSES

Burchell, Robert W. 1997b. *South Carolina Infrastructure Study: Projection of Statewide Infrastructure Costs, 1995-2015.* New Brunswick, NJ: Center for Urban Policy Research, Rutgers University.

This study involves a 20-year projection of infrastructure need in the State of South Carolina. It encompasses all public and quasi-public infrastructure required in the state including developmental (roads, bridges, water/sewer), educational,

commercial, public safety, public health, recreational/cultural, and environmental. Twenty-eight individual categories of infrastructure are contained in the above seven groupings listed above. Findings for the state are as follows:

- $56.7 billion in required infrastructure costs from 1995-2015
- $16.7 billion in potential infrastructure savings due to technology, differing means of provision, and costs of sprawl savings. Much of the above savings to come from technology and differing means of provision, as opposed to costs of sprawl savings
- Three-quarters of the remaining $40 billion ($2 billion per year for 20 years), or an average of $1.5 billion annually, could be raised via 10 percent infrastructure set-asides in all state, county, municipal, and school district general fund budgets and intergovernmental transfer revenues
- The remaining $500 million annually must be raised from a variety of revenue sources, including property tax, sales tax, the tolling of roads, development impact fees, water/sewer charges and the like. A 2¢/gallon gasoline tax increase would raise only $56 million in revenues annually for infrastructure purposes.

Burchell, Robert W. 1992a. *Impact Assessment of the New Jersey Interim State Development and Redevelopment Plan. Report II: Research Findings.* Trenton: New Jersey Office of State Planning.

This study is an analysis of the effects of implementing a managed growth strategy in the state of New Jersey in the form of a State Plan. Two alternative futures are modeled—one with development as usual (TREND), and one with development according to the proposed State Development and Redevelopment Plan (PLAN).

The study showed that the state could save $1.4 billion in infrastructure funding over 20 years for roads, utilities, and schools, if it followed the PLAN versus the TREND scheme. This savings occurred mainly through more intensive use of existing infrastructure, as opposed to building additional infrastructure. The PLAN approach directed new growth to where excess capacity existed, rather than to virgin territories. The PLAN scheme was also more compact than the TREND scheme, therefore requiring less distance to be covered when linking developments by local and county roads. In addition, concentrating larger numbers of people in more compact areas provides for economies of scale, such as larger water and sewer treatment facilities, with lower costs per individual user. The Rutgers study, using the same increases in population (520,000 persons in 20 years), jobs, and households, for both TREND and PLAN, found that PLAN would save:

- $699 million in roads—a 24 percent savings
- $561 million in water and sewer costs—a 7.6 percent savings
- $173 million in school capital costs—a 3.3 percent savings
- $1.4 billion, overall, or just under 10 percent of all development-related (roads, water/sewer, public buildings) infrastructure expenditures.

Burchell, Robert W. et al.

1. ***The Economic Impacts of Trend versus Vision Growth in the Lexington Metropolitan Area.*** **Report Prepared for Bluegrass Tomorrow, Lexington, KY. 1995b (November).**

2. ***Impact Assessment of DELEP CCMP versus STATUS QUO on Twelve Municipalities in the DELEP Region.*** **Report Prepared for by the Government Committee of the Delaware Estuary Program. Philadelphia, PA. August 15, 1995.**

3. ***Fiscal Impacts of Alternative Land Development Patterns in Michigan: The Costs of Current Development Versus Compact Growth.*** **Southeast Michigan Regional Council of Governments. 1997a.**

These three studies extend and broaden the application of Burchell's New Jersey modeling of development alternatives (sprawl versus compact growth) to different geographic settings. A broader base enables refinement and testing of the models under different taxing structures, differing means of providing and funding infrastructure, and differing geographic levels of investigation.

Each of the studies—Lexington, Kentucky, the Delaware Estuary, and the State of Michigan—looked at the land, infrastructure, housing, and fiscal costs of sprawl versus compact development. Compact development was differently defined in each study; sprawl which was equated with historical development, varied only marginally from place to place. There was much more consistency in the definition of trend development or sprawl across these studies than there was in the specific alternatives to sprawl. Findings from the studies are included in the following table:

COMPACT GROWTH VERSUS SPRAWL DEVELOPMENT: FINDINGS OF MULTIPLE STUDIES

Area of Impact	Savings: Compact Growth Over Sprawl Development (Lexington, KY and Delaware Estuary Studies)	Savings: Compact Growth Over Sprawl Development (State of Michigan)
Developable Land	20.5–24.2%	15.5%
Agricultural Land	18-29%	17.4%
Fragile Land	20-27%	13.1%
Infrastructure		
Roads	14.8%-19.7%	12.4%
Utilities		
(Water/sewer)	6.7-8.2%	13.7%
Housing Costs	2.5-8.2%	13.7%
Fiscal Impacts	6.9%	3.5%

Duncan, James E. et al. 1989. ***The Search for Efficient Urban Growth Patterns.*** **Tallahassee: Department of Community Affairs.**

This analysis encompasses detailed case studies of the actual costs (and revenues) incurred by several completed residential and nonresidential projects throughout Florida. The projects chosen are representative of five different development patterns ranging from "scattered" to "compact." Although the Florida study did not intend such an analysis, it is possible to group the five development patterns into two aggregate development profiles, "trend" and "managed/planned" growth. The term "trend" includes the Florida development patterns labeled "scattered," "linear," and "satellite"; the term "managed/planned" refers to the Florida patterns of "contiguous" and "compact" growth. With this grouping, the relative capital costs for trend versus managed or planned growth can be determined from the base Florida case study information. The data show that the total public capital costs for a detached unit built under trend conditions in Florida approached

$16,000; under planned development the capital cost was about $11,000 per unit, or roughly 70 percent of the cost of "trend" (see table below).

CAPITAL FACILITY COSTS UNDER TREND VERSUS PLANNED DEVELOPMENT
(PER DWELLING UNIT; 1990 DOLLARS)

Category of Capital Costs	Average of Case Studies Under Trend Development	Average of Case Studies Under Planned Development	Trend Versus Planned Development Difference	#/%
Roads	$7,014	$2,784	(+) $4,230	60.3
Schools	6,079	5,625	(+) 545	7 4
Utilities	2,187	1,320	(+) 867	39.6
Other	661	672	(-) 11	1.7
Total	15,941	$10,401	(+) 5,4540	36.7

ECONorthwest. 1994. *Evaluation of No Growth and Slow Growth Policies for the Portland Region.* Portland, OR: Metropolitan Portland Government.

As part of its *Region 2040* planning program, Metro (Portland, Oregon's metropolitan area's regional government) evaluated alternative futures for the region and the policies available to achieve those futures. This report examined whether the region could or should adopt policies to reduce and slow the anticipated growth in the region.

The study identifies both reactive and proactive policies which would slow growth. Reactive policies would discourage growth through a municipality's economic development activities, its investment in infrastructure and public facilities, and its programs for environmental amenities and social services. Proactive government policies would discourage growth by limiting the supply and use of buildable land (via zoning and planning regulations), charging more for public facilities, and imposing increased environmental and design standards on existing and new developments.

The authors concluded that while municipally initiated reactive or proactive policies would slow growth in the short run at the local level, a viable strategy for the Portland metropolitan area must be implemented at a regional scale, so that aggregate growth is decreased and not simply redistributed within the metropolitan area.

Finally, the study pointed out that although not always considered, slow growth policies could have negative effects on the local economy. These include decreased economic opportunities and income growth, and increased housing costs.

Fodor, Eben V. 1997. "The Real Cost of Growth in Oregon" *Population and Environment* 18-4.

Oregon municipalities levy *system development charges* to offset development costs. Within Oregon, for a typical three-bedroom home, these development charges can range from $1,000 to $6,500 per unit. Fodor, however, conservatively estimates that the actual public cost is closer to $24,500 per unit. He provides a breakdown as shown in the table below.

Fodor concludes that Oregon (like other states) is only recovering a fraction of the public infrastructure costs through *system development charges* and other development fees. Rather, he postulates that communities are subsidizing growth by keeping housing prices artificially low. Implementing growth management strategies, while providing these subsidies, works at cross purposes. Fodor suggests that communities should pursue alternatives, such as the public acquisition of land to prevent development, as a viable, cost-saving policy for growth management.

DEVELOPMENT COSTS (PER DWELLING UNIT)	
Public Service	Amount
School Facilities	$ 11,377
Sanitary Sewage Facilities	5,089
Transportation Facilities	4,193
Water System	2,066
Parks and Recreation	797
Stormwater Drainage	510
Fire / EMS facilities	470
Total	24,502

Frank, James E. 1989. *The Costs of Alternative Development Patterns: A Review of the Literature.* Washington, DC: Urban Land Institute.

This study reviews the national literature conducted over roughly four decades concerning development costs. Frank orders the findings of the various reports and expresses them in equivalent dollar terms (1987 dollars). He concludes from the national literature that multiple factors affect development costs including density, contiguity of development, distance to central public facilities (e.g., sewage and water plants), as well as other characteristics, such as municipal improvement standards. In brief, capital costs are highest in situations of low-density sprawl, and for development located a considerable distance from central facilities. By contrast, costs can be dramatically reduced in higher-density development that is centrally and contiguously located. As described by Frank:

> When all capital costs are totaled ... the total cost for low-density ... sprawl ... is slightly more than $35,000 per dwelling unit. Further, if that development is located 10 miles from the sewage treatment plant, the central water source, the receiving body of water, and the major concentration of employment, almost $15,000 per dwelling unit is added to the cost, for a total of $48,000 per dwelling unit ...
>
> The cost can be reduced to less than $18,000 ... by choosing a central location, using a mix of housing types in which single-family units constitute 30 percent of the total and apartments 70 percent, and by planning contiguous development instead of leapfrogging. (Frank 1989, 39)

To the extent that planned or managed growth fosters the more efficient patterns described above—centrally located, contiguous development that includes units at somewhat higher density—it can achieve infrastructure savings relative to traditional development.

Peiser, Richard B. 1984. "Does It Pay to Plan Suburban Growth?" *Journal of the American Planning Association* 50: 419-433.

The aim of this study is to provide a comprehensive method for comparing one development pattern to another. To achieve this aim, Peiser conducts a quasi-controlled experiment comparing the planned development of a 7500-acre tract in southwest Houston with the hypothetical "unplanned" development of the same tract. Peiser patterns unplanned development after development that occurred to the north of Houston in an area called Champions. The author evaluates the capital costs associated with land development and transportation for each of the two development alternatives. Other social costs are also examined in a qualitative analysis. Unlike previous studies, Peiser includes non-residential land uses in his analysis.

Peiser makes four assumptions in his comparison. First, total density and total acreage of each case is assumed to be equal. Second, he assumes that each community derives the same level of total benefits. The relative advantage of one community over the other is determined by the differences in costs associated with each type of development. Third, the study focuses upon the differences in costs of the overall community design, not the costs associated with differences in housing, building types, interior streets or utilities for residential subdivisions. Finally, travel costs are accounted for to and from the edge of the development site.

Peiser finds that planned development produces higher net benefits than unplanned development for the three cost components investigated: land development, transportation, and social issues. Overall, transportation costs provide the greatest net benefit. However, the magnitude of the difference is small, only accounting for one to three percent of total costs. Further, Peiser acknowledges the obstacles to planning large-scale developments. He highlights several constraints associated with such development including the cost and availability of financing, the labyrinthine permitting process, and the difficulties of managing large-scale projects.

Real Estate Research Corporation (RERC). 1974. *The Costs of Sprawl: Environmental and Economic Costs of Alternative Residential Development Patterns at the Urban Fringe: (Volume I: Detailed Cost Analysis; Volume II: Literature Review and Bibliography).* Washington, DC: U.S. Government Printing Office.

Among the most often cited studies in the history of planning literature, this three-volume series is the final report of an early effort to isolate the variable of density from those of structural age, obsolescent layout, and low-income population, in order to measure some of the most important and costly consequences of urban form. Sponsored jointly by the U.S. Council on Environmental Quality, the Department of Housing and Urban Development, and the Environmental Protection Agency, the project was carried out by the Real Estate Research Corporation. Its central conclusion, that low density development is extremely costly on energy, environment, and fiscal grounds, has been generally accepted as both intuitively correct and accurately determined.

The basic study method was to make detailed estimates of the costs associated with six hypothetical new communities—each containing 10,000 dwelling units, each housing an "average" urban fringe population mix, and each constructed in a "typical" environmental setting.

The report's basic conclusions are:

1) The high-density planned community would be optimal with reference to all four key indicators examined: energy cost, environmental impact, capital cost, and operating cost. The low-density sprawl community would be least desirable with reference to all four.

2) The high-density planned community would require 44 percent less energy than the low-density sprawl community.

3) The high-density planned community would generate 45 percent less air pollution.

4) The high-density planned community would require a capital investment 44

percent less than the low-density sprawl community; the largest proportionate savings would be in road and utility construction, but the largest absolute saving would be in the cost of residential construction itself.

5) The operating cost of community services would be about 11 percent lower in the high-density planned community than in the low-density sprawl community

A classic in its field, *The Costs of Sprawl* has not failed to attract criticism. Perhaps the most glaring limitation is that its energy, pollution, and capital cost comparisons all require correction. The authors assumed different space standards for the different types of dwelling units. The savings in capital and operating costs calculated in the report are mainly a function of the difference in size, not where these units are located or the density of their development. Furthermore, the energy savings attributed in the report to high-density development appear significantly overstated; and since the estimates of air pollution reduction was made a direct function of energy savings, these estimates must be deflated to a similar degree.

Despite these qualifications, *The Costs of Sprawl* merits the close attention of those interested in an analysis of urban form. Although it is important to recognize the fragility of the main conclusions of *The Costs of Sprawl,* it is equally appropriate to recognize this report as a landmark from which most research on the consequences of urban form has branched.

Souza, Paul. 1995. *New Capital Costs of Sprawl, Martin County, Florida.* Gainesville, Fl: University of Florida.

This is a study of the capital requirements of growth in a developing county in South Florida. Souza assumes that Martin County's population will grow at a similar rate as the rest of South Florida. He then calculates the density- and distance-related costs of providing certain public infrastructure. Costs associated with providing roads, a potable water supply, and sanitary sewers within three different housing densities (3, 5, and 10 units per acre) are assessed using Martin County-specific unit costs and development assumptions. Souza then computes costs associated with connecting three sites at varying distances from the urban service area.

Souza finds that the provision of infrastructure within the *lowest density* development is over 100 percent more costly than the provision of infrastructure within the *highest density* development. He also finds that distance costs can not be separated from density costs. As distance from the center increases, density decreases.

The provision of infrastructure to the *lowest density* housing pattern situated on the site *farthest* from the urban service area is 181 percent more costly than the provision of infrastructure to the *highest density* housing pattern situated on a site *within* the urban service area. Low-density sprawl is significantly more costly than high-density non-sprawl. Roads comprise the largest proportion of both density- and distance- related costs.

Tischler & Associates. 1994. *Marginal Cost Analysis of Growth Alternatives—King County, Washington.* Bethesda, MD: Tischler & Associates, Inc.

This paper was prepared for the King County, Washington Growth Management Planning Council (GMPC) to evaluate options for future development. The analysis consists of three basic land-use scenarios, with and without high capacity transit between planned urban centers, yielding five alternatives for study.

The study identifies the costs of new development for each alternative over a twenty-year projection period, estimating costs and revenues associated with growth for roads, transit, water and sewer utilities, and government administration.

The study draws the following conclusions:

- The alternatives with more development in the urban centers and cities are more fiscally beneficial when roads, utilities, and general fund activities are considered.
- The scenarios using eight centers generate higher net revenues for the general fund and utility districts than those with fourteen centers, because the eight-center scenarios assume fewer new households in the unincorporated counties inside the urban growth area (UGA) than do the fourteen-center scenarios.
- The fourteen-center scenarios indicate net road costs which are 11 percent below those of the eight-center scenarios. Road costs (especially rights-of-ways) are higher for the eight-center scenarios because these alternatives include major increases in new households and jobs, which entail both the construction of new roads and purchases of rights-of-ways in the maturing urban centers.

Windsor, Duane. 1979. "*A Critique of The Costs of Sprawl." Journal of the American Planning Association* 45, 2: (July) 279-292.

This article is a critical review of the RERC study, *The Costs of Sprawl.* The first part summarizes the findings from the RERC study. The author then criticizes RERC for not disentangling density from other factors. Windsor criticizes RERC for using different size units for different densities, i.e., smaller units for higher densities. Because smaller units have lower floor areas, they are less costly to build. This is a major reason why larger low-density, single-family units are considered more costly to build and to publicly service than higher-density units. Total floor area is 44 percent lower in high-rise developments than single-family neighborhoods. Differences in housing costs and public capital costs largely parallel these floor area differences.

Windsor recomputes the RERC analysis assuming all housing units are 1,200 square feet. This computation greatly reduces the housing and capital cost advantages of high density, though the advantages still exist. However, this approach is equally unrealistic. In reality, higher-density units are indeed smaller, on average, so RERC is not entirely wrong. Windsor concludes that the only way to avoid the problem is to calculate results for both methods on a per square foot basis and compare them.

Another criticism Windsor levels at the RERC study is that it assumes structure costs are highest for single-family homes,

lower for high-rise construction, and lowest for walk-up units. Windsor, in contrast, believes that high-rise units should have the highest costs per square foot. He also takes issue with RERC's assumption that developers have to contribute more land to the public sector under single-family development than under high-rise development.

RERC assumes that clustering in higher-density patterns results in savings of vacant land. But, Windsor argues that if the model assumed that a given amount of land is developed at different densities, the total population accommodated on the land could vary. Some ability to account for saved land when residents have more land immediately around them than permitted by existing zoning should have been developed.

The author also criticizes RERC for: "the underlying assumption that cost minimization is an appropriate principle for planning and development ... Cost minimization is not a planning principle unless benefits are constant." Since RERC ignores the benefit side, its conclusions of reduced costs ignore the reduced benefits. However, the author thinks it is not necessary to measure benefits. He claims the prevalence of low-density settlements reflects the benefits to consumers: "Consumers choose to live at high densities only where land costs are very high, as in central cities." Where land costs are lower, as in suburbs, they prefer low density environments.

The author claims that suburbs resist high density on several grounds, not just costs. "Voters are opposed to rapid population growth, the possible characteristics of new residents, the fiscal implications, and the loss of suburban amenities like open space, semi-rural ambiance, etc. Exclusionary land-use controls are intended, in part, to force low-density development; they function as a form of growth management." (291)

By ignoring these nuances, says Windsor, RERC "does not properly evaluate the relative economic efficiency of alternative development patterns." (291)

York, Marie L. 1989. *Encouraging Compact Development in Florida.* Fort Lauderdale, FL: Florida Atlantic University–Florida International University Joint Center for Environmental and Urban Problems.

York analyzes three areas: growth management programs from around the country (Maine, Massachusetts, New Jersey, Oregon, Vermont); innovative development strategies by region; and problems with redevelopment. The analysis of the statewide programs consists of descriptive summaries of state policies designed to address increasing growth management problems, as well as summaries of the situations that prompted the development of these policies. Each state's section concludes with a discussion of how well the policies and legislation have worked in achieving the state's goals. Some of the difficulties, noted by York, revolve around definitions of rural versus urban uses; areas that are exempted from the legislation for one reason or another; property taxes as a disincentive to compact growth; opposition from developers and municipalities; and the methods of determining urban growth boundaries.

The innovative development strategies section of this document examines the use of urban growth boundaries (UGBs)—a proactive growth management tool to contain, control, direct, or phase growth

close to existing urban development. Basic to this strategy is the delineation of perimeters around urban development areas, within which urban densities are normally encouraged, and outside which urban uses and densities are discouraged. Also discussed are transfers of development rights, point systems, and revenue sharing as means of growth management. All four of the subsections conclude with the experiences of communities in several states that have implemented these strategies.

The section on problems of in-fill and development provides overviews of issues and approaches, followed by discussions of programs and projects in Florida and other states.

A secondary analysis of several state studies is undertaken to quantify the impact of UGBs on land prices. However, York admits that the data are neither complete nor consistent enough to draw firm conclusions concerning the land price impacts of urban growth boundaries.

The report concludes with separate sets of recommendations for encouraging compact development, redevelopment, and in-fill development. The recommendations address land use, fiscal, and infrastructure issues.

FISCAL IMPACTS, EXACTIONS, AND IMPACT FEES

Altshuler, Alan. 1977. "Review of The Costs of Sprawl," *Journal of the American Planning Association* 43, 2: 207-209.

This short article reviews the RERC report and was published about two years after the report. The review is so clear and so well done that it changed forever the way the *Costs of Sprawl* report was viewed. For purposes of simplicity, Altshuler focuses on the two extreme cases analyzed by RERC—high-density multifamily housing and low-density single-family housing. He begins by summarizing the major findings of the RERC study. He then asks three questions: (1) Have the results of the theoretical analysis been calibrated against actual community experiences? (2) Does the report itself fully support the conclusions stated in its summary? and (3) Are the reported advantages of high-density over low-density development clearly differentiated as to reason? His answer to all three questions is "No"!

One key issue Altshuler raises is whether density per se affects the demand for community services. RERC explicitly assumes that it does not, but Altshuler challenges that assumption. Low-density areas often have no sidewalks; they have above-ground utility lines, and infrequent street lights, when measured against high-density areas. The demand for public safety services is also likely to be lower in low-density development. Further, RERC does not include any estimates of mass transit spending in its study, though such spending would surely be higher in high-density communities that rely more on mass transit. Therefore, Altshuler maintains high-density settlements are likely to have higher community service costs than low-density ones, which would offset many of the savings projected for the latter types of settlements.

According to RERC, the savings for high-density living versus low-density living are only $238 per year in operating costs, for a density rise from 3.5 to 19.0 units per acre plus more intensive planning. Four-fifths of the savings are attributed to density alone. Altshuler believes, given the omissions mentioned

above, that this small amount would vanish if the analysis were done correctly.

He also makes the point, which Windsor later picks up on, that dwelling units in the high-density settlement are 34 percent smaller than those in the low-density settlement, and this accounts for a large part of their differences in capital and energy costs. Five-sixths of the heating and air conditioning savings in high-density development is attributable to smaller housing unit sizes.

RERC further assumes that average annual travel per household in high-density developments is about 9,891 miles versus 19,673 miles per household in low-density developments. Generally, only local trips vary by density, but RERC fallaciously attributes cost savings to the entire travel mileage. According to Altshuler, correcting this error eliminates four-fifths of the claimed savings in auto energy consumption. With proper analysis, the total energy savings of high-density versus low-density development is about 3 percent, of which only 1 percent is attributable to density alone.

Another issue Altshuler addresses is whether higher residential density leads to higher density in other types of land uses. He thinks not: "The case that low-density living is a highly expensive luxury remains to be made" (209).

Nonetheless, the author commends RERC for having putting forth a systematic analysis that can serve as a starting point for other studies.

Altshuler, Alan A., and Jose A. Gomez-Ibanez. 1993. *Regulation for Revenue: The Political Economy of Land Use Exactions.* Washington, DC: Brookings Institution.

The central issues and themes of this text relate to government-mandated exactions paid by real estate developers. Exactions may be in-kind or involve monetary outlays. The legal theory underlying development exactions is that governments, having reasonably determined that certain public needs are "attributable" to new development, may require that their costs be "internalized" as part of the development process. A key premise of the argument for exactions is that land development is a major cause of escalating local infrastructure demands and costs.

This study looks at the costs of growth in built-up communities. Alternative estimates of revenues and expenditures for the city of San Francisco are discussed, as are approaches for allocating public expenditures for growth among county businesses and residents in Montgomery County, Maryland.

This text also critiques the Real Estate Research Corporation's *The Costs of Sprawl* study. As Altshuler found in his 1977 study, the principal problem with the RERC study is the meaning associated with the cost differences. Altshuler and Gomez-Ibanez argue that the degree of variation between the quality of housing units from one community to another does not allow costs to be fairly compared. If conditions can not be replicated in future studies, community cost impacts will continue to be difficult to compare.

Overall, the chapter on fiscal impact analysis reflects at least one of the authors' inexperience with this technique.

The authors rely too heavily on secondary analyses and critiques. Furthermore, the book does not give enough recognition to the role (both constructive and destructive) of fiscal impact analysis to either counter or abet development (sprawl) during subdivision or site plan review.

American Farmland Trust. 1986. *Density-Related Public Costs.* Washington, DC: AFT.

This study tests the hypothesis that, in rural areas, public costs for new residential development exceed the public revenues associated with this type of development. Using Loudoun County, Virginia data, the study attempts to develop a methodology to estimate: (1) the net public costs (public costs minus public revenues) of new residential development; and (2) how these costs vary with different development densities.

The study's methodology entails a four-step process. First, major categories of public expenditures (education, health and welfare, and safety) and public revenues (property taxes, state funds, and other local taxes) are identified, based on the county's annual budget. Second, the demographic profile of a 1,000-household new development is determined, based on surrounding demographics, to consist of 3,260 residents (including 940 school-age children). Third, four development scenarios are projected at different density levels, varying from 0.2 dwelling units (d.u.) per acre (rural, low-density) to 4.5 d.u. per acre (suburban, high-density), while retaining the demographic profile of the development. Finally, fiscal impact analysis models are run to determine public costs and revenues associated with each density scenario.

The results reveal a public revenue shortfall for residential development at all densities. However, the lowest-density development results in a shortfall three times larger than the highest density development ($2,200 per d.u. versus $700 per d.u.). To cover the shortfall, the county would have to apply some combination of reduced public services, higher taxes, or increased commercial zoning. In addition to imposing higher public costs, the lower-density developments also remove larger amounts of agricultural land—a result counter to Loudoun County's goal to preserve its agricultural economy.

American Farmland Trust. 1992a. *Does Farmland Protection Pay? The Cost of Community Services in Three Massachusetts Towns.* Washington, DC: AFT.

This report summarizes the American Farmland Trust's findings from studies of three Pioneer Valley, Connecticut towns (Agawan, Deerfield, and Gill). The report addresses the five basic steps undertaken by the studies: 1) discussions with local sponsors to define land-use categories (residential, industrial, commercial, and farm/forest/open land); 2) the collection of data for each town; 3) the review of public revenues, allocated by land use; 4) the review of public expenditures, allocated by land use; 5) data analysis and calculation of revenue-to-cost ratios.

This study is part of a series of studies on the costs and benefits of unimproved land as it relates to a community's fiscal well-being. The bulk of support for these analyses comes mostly from groups desiring to preserve agricultural lands in perpetuity as opposed to general academic inquiry into this area.

It is important to summarize the results of these studies before talking about methodologies. In general, they conclude that:

- Residential development does not pay its own way.
- Nonresidential development does pay its own way but is a magnet for residential development.
- Open space or agricultural lands have higher revenue-to-cost ratios than both residential and non-residential development.

Several aspects of the American Farmland Trust studies cause concern. For instance, these studies are not termed "fiscal impact" but rather *Cost of Community Service* (COCS) studies. They are not approached in a standard cost/revenue framework, yet they proffer standard fiscal impact conclusions.

Further, no one is viewed as being at home "tending" the farm. The farm contains no residents or workers. The costs/revenues for residents are deflected to other land uses—predominantly residential. No costs are assigned to agricultural workers, and no highway costs, garbage costs, traffic costs, or health/social service costs are assigned to the farm. Nor are municipal legal or election costs factored in.

- If a reasonable cost-assignment method could not be found, a "default" procedure was used, which assigned costs by the distribution of revenues or by the value of property. Given the low agricultural assessments, predictably large shares of local costs were assigned to residential and nonresidential uses; very small amounts were assigned to agricultural uses. The study's conclusions were blunt: The results of the study show that the residential category is being supported by the agricultural and commercial/industrial categories. The residential sector is demanding more in services than it is contributing in revenues.
- This study provides a fiscal argument for the protection of farmland and open space.

Despite the lopsided findings of the study, the fact remains that fiscal impact relationships between agricultural and other land uses are not well-documented. Most of the cost and revenue calculation procedures developed since *The Fiscal Impact Handbook* (Burchell and Listokin 1978), ignore open space and agriculture as either a significant cost or revenue. All costs are assigned to the residential and nonresidential sectors, and all forthcoming revenues come exclusively from developed properties whether or not they have inclusive open space. Most studies assume that open space or unimproved lands have neither a significant negative nor positive cost/revenue impact, which is probably an accurate assumption. Neither agricultural nor open space lands cost very much or provide much in local revenue.

Buchanan, Shepard C. and Bruce A. Weber. 1982. "Growth and Residential Property Taxes: A Model for Estimating Direct and Indirect Population Impacts." *Land Economics* 58, 3 (August): 325-337.

Buchanan and Weber's analysis is an attempt to determine the extent to which population growth affects single-family residential property taxes, and how these effects are transmitted. To answer these questions, the authors examine both tax rates and assessed values of properties in Oregon, and the possible influence of increased population on each of these variables. Among other procedures, they

study intermediate variables, such as age of housing stock, personal income, and population density.

The authors find that up until 1979, increases in new single-family homes apparently both directly increased average homeowner assessments and indirectly increased tax rates on *all* properties. In 1979, however, the Oregon legislature enacted a tax relief program under which the average rates of increase in assessed valuation of both residential property and all other property on a statewide basis were limited to a maximum 5 percent per year. After this change was enacted, assessments and tax rates slowed in their rate of increase. The costs of servicing new properties could no longer be "exported" to old properties beyond a fixed percentage per year.

The authors suggest that similar legislation be enacted in other states where there is a quest for homeowner property tax relief. They assert that the model they developed for local governments in Oregon is generalizable to other states with similar tax systems. In addition, they believe that the model could be adapted for use in analyzing the impact of population growth on the tax bills of owners of all types of property.

Dougharty, Laurence, Sandra Tapella, and Gerald Sumner. 1975. *Municipal Service Pricing Impacts on Fiscal Position.* Santa Monica, CA.: RAND.

This report analyzes the impact of alternative municipal service pricing policies on urban structure and on a community's financial position. A pricing policy is a method of allocating the cost of a service to one sector or another of the community (e.g., new residents, existing residents, the entire community). In this report, primary attention is paid to pricing policies for the capital infrastructure required to service new development.

The pricing structures estimated in the report are developed using actual data from San Jose and Gilroy, California. San Jose is a fairly large city that has already experienced fairly rapid growth; Gilroy is a city that could potentially undergo explosive growth. Both are believed by the authors to be prototypical of a number of American cities.

This analysis finds that pricing policies allocated to the largest base of payees has the least overall negative effect on the economy of the community.

Downing, Paul, ed. 1977. *Local Services Pricing and Their Effects on Urban Spatial Structure.* Vancouver: University of British Columbia Press.

The central claim of this book is that local governments are increasingly turning to alternative sources to raise revenues. Many now impose user charges.

A user charge is an explicit price on the consumption of a public service. In addition to being a source of revenue, user charges are also a direct measure of taxpayers' willingness to pay for the services provided by local government. A user charge makes the payment explicit and directly associated with the public service that is being delivered. It gives the taxpayer a better understanding of what the choices are, enabling a more intelligent decision regarding the array of goods provided by local government. In addition, the user charge performs the function of price. It rations demand, according to who values the service most highly.

The first section of this book presents the rationale for developing new sources of

revenue for local government. It identifies the possible scope of user charges as a means of filling this demand, and presents a detailed examination of how a user charge is designed and calculated. The second section presents an analysis of spatial variation in the costs of providing public services. The third section is concerned with institutional systems and their effects on the financing and supply of services. The fourth section argues that while location may not affect costs, political bodies are willing to account for cost differences in the way they assign user charges. The final section presents the author's conclusions about the findings and relates their implications for future policy.

DuPage County Development Department. 1989, 1991. *Impacts of Development on DuPage County Property Taxes.* DuPage County, IL: DuPage County Regional Planning Commission.

Five years ago, a brouhaha emerged in the Chicago area involving the cost of nonresidential uses. Debate in DuPage County centered on whether or not commercial uses paid for themselves. A number of experts subsequently gathered to evaluate the findings of the DuPage County Planning Commission's study, *Impacts of Development on DuPage County Property Taxes.*

A regression analysis by DuPage County inferred *a strong relationship between nonresidential development and property tax increases.* Although preservationists leaped to defend these findings, others pointed to the weaknesses of the study. The most convincing of the critiques took a position in the middle—pointing out that some evidence backed up the findings of DuPage County, but the evidence was not nearly as strong as had been presented in the report.

The DuPage County report is not a classic fiscal impact analysis, but rather a regression equation in logarithmic form. The dependent variable is total property taxes levied; independent variables include change in nonresidential firms, change in ratio of nonresidential-to-residential equalized valuation, median residential property tax levy, and the ratio of taxes to the total municipal equalized assessed valuation.

Some critics of the analysis believed both sides of the regression equation formed an identity, whose intercorrelation prevented solution. Some thought the research design should undergo significant alteration; others thought both dependent and independent variables should be recast. DuPage County, however, continued to defend both the analysis and its results.

In reality, the analysis must be put into a fiscal impact frame wherein *all* costs can be compared to *all* revenues. In addition, the quality and quantity of services, the relative levels of tax and nontax revenue, the presence of deficient or excess service capacities, and the effects of other land uses in similar situations should be viewed. A number of studies with similar conclusions about nonresidential growth's impact on property taxes have been documented. Most results can be traced to the nonaccountability of elected/appointed officials, which in turn led to significant service increases for primarily nonresidential properties.

The DuPage study points out that nonresidential development and its associated surplus fiscal revenues could improve service quality and quantity in a community. However, it may also increase local expenditures. Without knowing the type and quantity of public services produced before and after the nonresidential development is put in

place, no judgment can be made about nonresidential development and future tax rates.

Logan, John, and Mark Schneider. 1981. "Suburban Municipal Expenditures: The Effects of Business Activity, Functional Responsibility, and Regional Context." ***Policy Studies Journal*** **9: 1039-50.**

The authors set out to explain the variations in the level of suburban government spending. They first summarize existing explanatory models, which stress either local stratification and discrimination, the structure of local decision making, ecological position, or public choice. These models suggest varying hypotheses about which suburbs spend more and which less. Logan and Schneider then evaluate each of the alternative models and propose major directions for further research.

The authors conclude that each model has its strengths and certain hypotheses from each is supported by the data. Certain variables stand out, however, as having particularly strong explanatory power in all models. The strongest, in terms of determining suburban expenditures, is economic function. Regardless of any other differences among communities, suburbs with strong employment bases spend more than those with weak employment bases.

Of nearly equal importance is the set of service responsibilities that a suburban municipality assumes. This finding may take historical inquiry to fully explain.

Finally, differences in SMSA structure are shown to explain part of the expenditure variation, although no simple reason is given for this influence. Instead, the authors call for additional research to be directed towards explaining what kinds of economic, historical, political, or social situations cause the differences in suburban expenditures detected in this study.

THE EFFECTS OF GROWTH CONTROLS ON HOUSING COSTS

Katz, Lawrence, and Kenneth Rosen. 1987. "Interjurisdictional Effects of Growth Controls on Housing Prices." ***Journal of Law and Economics 30*** **(April): 149-160.**

In this article, Katz and Rosen argue that the widespread proliferation of land use and environmental regulations, primarily imposed by local governments, forces the home-building industry to work within a much more complex and often more costly regulatory framework.

Local governments have used a wide variety of procedures to control residential development, and these controls have become increasingly complex and innovative over time. In many municipalities, traditional land-use controls have been augmented by environmental and fiscal impact procedures, urban growth management systems, utility connection moratoria, multiple permit systems, overall growth limitations, or a combination of these measures.

Katz and Rosen examine the effects of local land use regulations on house prices in the San Francisco Bay Area. They find that land use regulations appear to have had a substantial effect on housing prices. The authors conclude that the widespread use of controls in communities limits available housing supply. The spread of these regulatory techniques to metropolitan areas outside California could have substantial negative effects on

the affordability of housing in these locations.

Parsons, George. 1992. "The Effects of Coastal Land Use Restrictions on Housing Prices." ***Journal of Environmental Economics and Management*** **(February): 25-27.**

In this paper, the author estimates the effect on housing prices of land-use restrictions for property abutting the Chesapeake Bay. He examines the change in housing prices before and after the introduction of restrictions in Anne Arundel County, the most populated of the 16 counties that were affected. The price changes are compared to the change in housing prices in several inland locations, not affected by the restrictions, over the same monitoring period.

Parsons finds that the coastal land-use restrictions appear to have caused a considerable increase in housing prices. To make this assertion, he assumes that, absent the controls, the change in housing prices in coastal areas would have been the same as it was for inland locations. Except for land use restrictions, the author believes, both locations share the same general market conditions. This is a significant assumption, considering the effect of "water frontage" on housing price.

Parsons also believes that the land use restrictions create winners and losers in the local housing market. The winners are the current owners of housing in the community. The losers include current owners of undeveloped and restricted land, renters, and future purchasers of housing in the coastal community.

Parsons closes with an admonition that the large transfer of wealth from future residents to current residents through housing price increases, and the absence of future residents in the political process in which the restrictions were established raise suspicion about the fairness and efficacy of these regulations.

Propst, Luther, and Mary Schmid. 1993. ***The Fiscal and Economic Impacts of Local Conservation and Community Development Measures: A Review of Literature.*** **Tucson, AZ: Sonoran Institute.**

The authors undertook an effort to review about 200 articles and other publications, with a special emphasis on those dealing with actual experiences in real communities. This literature review includes economic studies of the impacts of zoning and other land use regulation, and the economic impacts of a community's appearance, architecture, and natural environment.

Both a subject-related analysis and annotations of the more important studies appear in this review.

The author's general conclusion is that environmentally sensitive land use planning need not have a detrimental effect on real estate values, economic vitality, or the local tax base. Rather, the opposite is often true.

The authors close on the optimistic note that the lessons contained in the studies may help Greater Yellowstone (near Bozeman, Montana) communities successfully manage rapid growth and change as they choose their own futures.

Schwartz, Seymour I., David E. Hansen, and Richard Green. 1981. "Suburban Growth Controls and the Price of New Housing." ***Journal of Environmental Economics and Management*** **8 (December): 303-320.**

In this paper, the authors study the effects of suburban growth control programs upon the price of new housing. The programs that limit growth employ a variety of devices, including phased zoning, reduced development densities, and increased development charges. Some programs take an even more direct approach, by setting restrictions on the number of housing units permitted, or by imposing population or housing unit caps. The authors then analyze the effects of perhaps the most direct form of control: the housing quota of Petaluma, California.

To estimate price effects, the authors compare price changes of new single-family housing in Petaluma between 1969 and 1977 (after the quota was enacted) to the price changes in two nearby communities. The authors limit the analysis to new housing because it provides a relatively consistent basis for evaluation.

The study's results suggest that Petaluma's growth control program was responsible for an increase in housing prices. Because of the complexity of the issue, however, a totally unambiguous finding is not possible.

The authors are more confident when describing the effect of growth controls on the quality of construction. Here, they find evidence that higher construction quality and prices are attributable to growth controls. The authors close by calling for additional research to analyze the effects of growth controls on housing price.

Schwartz, Seymour I., Peter M. Zorn, and David E. Hansen. 1989. "Research Design Issues and Pitfalls in Growth Control Studies." ***Land Economics,*** **62, (August): 223-233.**

In this article, the authors analyze the experiences of Davis, California, a community that attempted to mitigate the effects of growth controls on the price of housing. The authors seek to determine whether Davis was successful in reducing the expected increase in the per-unit price of housing services due to growth control, and also to determine the extent to which Davis was successful in limiting the exclusionary impact of growth controls on lower income households.

The authors discover that growth controls increased per-unit housing prices due to the reduction in supply, but that price-mitigating programs are also effective. Furthermore, the incentives created by price-mitigation lead developers to build smaller, lower quality units.

Surprisingly, the study's results also show that growth controls increase the sales price of older housing, but the per-unit price declines, implying an increase in the quality of old houses sold. This is explained by the fact that the decrease in the quality of new housing may have encouraged households desiring higher quality (larger) housing to turn to the older housing market, resulting in an increase in the demand for higher quality older homes.

The authors conclude that price-mitigating measures are only partially successful in reducing the price effects of growth controls, since they mostly shift the impacts of growth controls from the new to the old housing market.

URBAN FORM AND SPRAWL

Black, Thomas J. 1996. "The Economics of Sprawl," *Urban Land* 55, 3.

For most businesses, the decentralization of activity and improvements in communications and transportation create a choice of location options. In addition, globalization trends (particularly in the production of some goods) are placing many U.S. businesses under increasing competitive pressure. According to Black, low-density, dispersed urban settlement patterns result from these powerful economic forces that continue to be driven primarily by changing transportation costs and production requirements.

The major benefit to businesses and residents in metropolitan areas of the dispersed settlements is reduced land rents, writes Black. Increased location options and lower transportation costs mean highly competitive land markets and, consequently, lower land prices, giving U.S. firms a significant advantage over their foreign competition. This translates into more competitive pricing by U.S. firms, a lower cost of living for workers, and higher returns on financial capital and labor.

It is obvious that high-density urban areas make sense only for economic activities that can justify hefty rents. As an alternative, extended transportation systems and lower-cost truck transportation also have enabled industrial and warehouse facilities to spread out to less dense locations to save money on building and land costs.

Black points out that another major issue surrounding current development patterns is the extent to which general taxpayers, especially those in built-out communities, subsidize new incremental, low-density development. Examples include subsidies in the form of income tax mortgage, interest, and property tax deductions; federal highway expenditures in excess of user taxes and fees; and state and local government subsidies for infrastructure expansion to support new development.

Views on these issues differ, and Black ends this article by calling for a realistic analysis of the forces at work to avoid faulty conclusions about the economics of sprawl.

Ladd, Helen, and William Wheaton. 1991. "Causes and Consequences of the Changing Urban Form." *Regional Science and Urban Economics* (21): 157-162.

The papers compiled in this work were initially presented at a conference on the *Causes and Consequences of the Changing Urban Form*, October 1990, run under the auspices of the Lincoln Institute of Land Policy. The goal of the conference was to bring together empirical, theoretical, and policy-oriented economists to improve the understanding of the nature, causes, and implications of polycentrism in metropolitan areas.

Recently, older, traditionally monocentric cities, such as Boston and Chicago, have developed significant suburban subcenters. Other newer cities, such as Phoenix, Dallas, and Los Angeles are perceived as lacking in any sense of "centrality."

Two of the papers in this collection provide insights on the nature and function of employment subcenters and decentralization; two develop and test empirical models that specifically include elements of polycentrism. One paper provides a new theory of subcenter formation in the context of a dynamic

model; and two more examine various implications of changing urban form for labor markets.

McKee, David L. and Gerald H. Smith. 1972. "Environmental Diseconomies in Suburban Expansion." ***The American Journal of Economics and Sociology*** **31, 2: 181-88.**

In this paper, the authors set out to isolate and analyze the components of suburban sprawl. Causes of sprawl are discussed, and an attempt is made to specify the economic effects sprawl has on urban areas, people, and the economy. The authors intention is to develop suitable policy recommendations for dealing with sprawl.

The authors conclude that sprawl appears to be the result of strong market forces, and that solutions to the problem may be beyond the abilities of public policy makers to solve. They call for more government intervention, especially at the local level, and for action on the part of regional planning agencies. To date, these institutions have not been able to deal adequately with the problem, because of overlapping jurisdictions and other political considerations. The authors further call for greater cooperation and sharing of resources at all levels of government to find solutions to suburban sprawl.

Mills, David E. 1981. "Growth Speculation and Sprawl in a Monocentric City." ***Journal of Urban Economics*** **10: 201-226.**

Mills presents an economic theory of sprawl in a growing, monocentric city. He posits that where decision makers have perfect knowledge, leapfrog development and discontinuous land-rent functions may occur and be efficient in both an ex-post and ex-ante sense. Where the extent of future growth is uncertain, decision makers become speculators, and the spatial pattern of development is more complicated. Ex-post inefficiency generally occurs.

In the context of Mill's formal monocentric-city model, three land-use patterns qualify as examples of sprawl. *Leapfrog development* occurs when a von Thunen ring of undeveloped land separates rings of developed land. This form of sprawl involves radical discontinuity. *Scattered development*, the second form of sprawl, occurs when there are annuli with both developed (homogeneously) and undeveloped land in them. *Mixed development* occurs when there are annuli with more than one developed use. Scattered development and mixed development forms of sprawl involve circumferential discontinuity.

Mills provides theoretical explanations for each form of sprawl. Leapfrog development can be explained by intertemporal planning on the part of decision makers who anticipate future growth with certainty. The essential idea here is similar to the notion put forth by Ohls and Pines (1975), that is, that land inside of the urban fringe is sometimes withheld from early development and preserved for more remunerative future options. Theoretical explanations for scattered and mixed development forms indicate that decision makers are uncertain about future growth and make speculative decisions.

Several criticisms of sprawl are cited and addressed with evidence generated from the monocentric city model constructed for this analysis.

Ohls, James C., and David Pines. 1975. "Discontinuous Urban Development and Economic Efficiency." ***Land Economics*** **3 (August): 224-234.**

Many observers argue that discontinuous development (wherein land that is closer to urban centers is skipped over in favor of land further away) is inefficient for several reasons. First, this development pattern fails to make use of the most accessible land. Second, the expense of providing public services, such as roads and sewage systems, to new development is high. In contradiction, Ohls and Pines argue that discontinuous development may be desirable and efficient in certain cases. For instance, the development of retail and commercial services near the urban fringe must often wait for the maturation of critical scale. In rapidly expanding urban areas, contexts arise in which it may be efficient to skip over land for a period of time in order to reserve it for commercial uses after market scale increases.

This strategy has been implemented in some planned communities. In Columbia, Maryland, for example, the planners of this "new town" explicitly reserved vacant land in residential areas for the development of shopping clusters in the future—after increased residential densities make such shopping enterprises economically feasible.

Peiser, Richard B. 1989. "Density and Urban Sprawl." ***Land Economics*** **65, 3 (August): 193-204.**

In this article, Peiser argues that, contrary to accepted thinking, if a free urban land market were allowed to function it would inherently promote higher-density development. He offers theoretical arguments and empirical evidence to support this thesis.

Peiser argues that *uniformly* low-density urban development is inefficient, because it increases transportation costs, consumes excessive amounts of land, and adds to the cost of providing and operating public utilities and public services. Furthermore, he claims that the data show that over time discontinuous development patterns actually promote *higher* density. So public policies aimed at preventing discontinuous development may be misguided. They may lead to development patterns in which densities might be lower than they ordinarily would be without such a policy.

Three case studies (Dallas, TX; Montgomery County, MD; and Fairfax County, VA) are presented in which lot sizes are examined over time along major arterial roadways. Higher densities (i.e. smaller lot sizes) are found in later in-fill development.

Peiser concludes that polices that encourage sequential development should be avoided. Instead, he argues that a competitive land market will achieve higher density through discontinuous development followed by later in-fill development.

CHAPTER 10

Annotations of Studies

TRANSPORTATION AND TRAVEL COSTS

Transportation and travel costs as they relate to sprawl involve mode of travel, pattern of residential development and development access, density of residential development, and location/type of non-residential development. The specific topics that group the annotations of this section reflect the above topical concerns. They are:

Changes in Automobile Travel
The Effects of Density on Travel Choices
Unlimited Outward Extension
Spatial Segregation of Uses
Dispersed Employment
The Costs of Travel

Changes in Automobile Travel includes the works of Gordon and Richardson (1989, 1991) and Alan Pisarski (1992). *The Effects of Density on Travel Choices* includes the works of Anthony Downs (1992), Robert Cervero (1991b, 1996), Frank and Pivo (1994), John Holtzclaw (1990, 1994), and Newman and Kenworthy (1989). *Unlimited Outward Extension* includes the works of Judy Davis (1993) and Parsons Brinckerhoff (1997). *Spatial Segregation of Uses* includes the works of Robert Cervero (1989, 1995, 1996), Reid Ewing (1994), S. Handy (1992, 1995), Robert Kitamura et al. (1994), and Parsons Brinckerhoff (1996c). *Dispersed Employment* includes the works of Robert Cervero et al. (1996, 1997). *The Costs of Travel* includes the works of Apogee Research (1994), M. E. Hanson (1992), J. J. MacKenzie et al. (1992), Parsons Brinckerhoff (1996a), and Michael Voorhees (1992).

CHANGES IN AUTOMOBILE TRAVEL

Gordon, Peter, Harry W. Richardson, and Myung-Jin Jun. 1991. "The Commuting Paradox: Evidence from the Top Twenty." *Journal of the American Planning Association* 57, 4: 416-20.

This comparison of mean commuting times of residents of core counties in the 20 largest U.S. metropolitan areas shows that average trips times declined or remained the same between 1980 and 1985, even as population increased in most areas. The authors hypothesize that constant or declining trip times were the result of commuters changing residences or jobs so that their origins and

destinations were closer to each other or so they could travel faster on less congested routes. However, the *American Housing Survey* database they use does not contain the information needed to confirm or disprove this hypothesis.

Levinson, D. M., and A. Kumar. 1994. "The Rational Locator: Why Travel Times Have Remained Stable." *Journal of the American Planning Association* 60: 319-332.

The authors compare travel diary data from the Washington, DC metropolitan area for the years 1968 through 1988. They conclude that greater dispersion of activities has helped keep travel times constant. During this 20-year period, the metropolitan area became more dispersed; population grew by 30 percent, employment grew by 85 percent, and the number of daily motorized trips per person increased from 2.3 to 2.8. Yet, differences of means test show that for most modes and purposes, average times for home-to-work and work-to-home were the same at the beginning and end of the period. The authors conclude that the "locators"—households and firms—acted rationally and relocated to keep travel times constant.

Pisarski, Alan E. 1992. *New Perspectives in Commuting.* Washington, DC: U.S. Department of Transportation. July.

Pisarski identifies trends in commuting using data from the *1990 Census* and the *1990 Nationwide Personal Transportation Study*. He shows that the proportion of all trips that were for work purposes declined slightly, from 20.4 percent in 1983 to 20.1 percent in 1990. Although the miles of travel for work increased, average travel times for work trips increased by only 40 seconds. This result is partly due to a 35 percent increase in the number of work trips made in single-occupant vehicles, usually the fastest mode of travel. The additional 22 million people who drove alone exceeded the number of workers added to the labor force. Meanwhile, the absolute number of people using transit remained at about 6 million, but the share of users declined due to population growth.

Richardson, Harry W., and Peter Gordon. 1989. "Counting Nonwork Trips: The Missing Link in Transportation, Land Use, and Urban Policy." *Urban Land* (September): 6-12.

One recent transportation phenomenon in the United States has been the growth in non-work travel, both during peak and off-peak hours. Using data from the *Nationwide Personal Transportation Studies for 1977 and 1983*, the authors find that the number of non-work trips increased three to four times faster than work trips during that time frame in all sizes of SMSAs. Non-work travel even increased faster than work travel during the peak periods. Richardson and Gordon contend that suburbanization, especially in the largest metropolitan areas, was a principal cause of the increase in non-work travel, although they acknowledge that demographic and workforce changes were probably also involved. Suburbanization of businesses means that suburbanites have more close-by shopping and recreational opportunities and, therefore, may make more trips to satisfy immediate needs rather than wait until they have a list of needs. The study, however, does not demonstrate either that shopping and recreational opportunities have increased in suburbia or that households take more trips because of such an increase. Nor does the study rule out the effects of other factors such as

rising incomes, greater participation of women in the workforce, and changes in leisure activities on non-work travel choices.

Rossetti, M. A., and B. S. Eversole. 1993. *Journey to Work Trends in the United States and Its Major Metropolitan Areas, 1960-1990.* Washington, DC: U.S. Department of Transportation.

The authors compare mean commuting times in 1980 and 1990 for the 39 metropolitan areas with populations in excess of one million in 1990. They find that commuting times increased in 35 of the metropolitan areas, and that the increases ranged from 0.47 percent in Philadelphia to 13.69 percent in San Diego. All four of the metropolitan areas with commuting time increases of more than 10 percent are Sunbelt cities: Los Angeles, San Diego, Sacramento, and Orlando. The only cities where commuting time declined are New York (-7.70 percent), Pittsburgh (-1.05 percent), New Orleans (-0.57 percent), and Salt Lake City (-1.92 percent).

THE EFFECTS OF DENSITY ON TRAVEL CHOICES

Simulations

Downs, Anthony. 1992. *Stuck in Traffic: Coping with Peak Hour Congestion.* Washington, DC: Brookings Institution; and Cambridge, MA: Lincoln Institute of Land Policy.

Downs develops a hypothetical urban area model to test the extent to which changes in the location and density of development would change average commuting distances. The basic model uses values for the proportion of jobs in the CBD, central city, suburbs, and exurbs, and commuting distances similar to the averages for large metropolitan areas. Different densities are created by varying the size of the suburbs and exurbs (and adjusting the proportion of population and jobs in each area as needed to match the size). The study shows that the density of growth at the urban fringe has a significant impact on commuting distances; a move from very low to medium densities has the greatest impact. Increasing exurban densities from 886 persons per square mile to 2,800 reduces commuting distances by 8 percent. An increase from 886 persons to 4,363 persons per square mile decreases commuting trip lengths by 14 percent. Beyond that, large increases in density shorten trips by only a small amount.

Ewing, Reid. 1997b. *Transportation and Land Use Innovations.* Chicago, IL: Planners Press, American Planning Association.

The author's goal in this book is to provide suggestions for improving mobility by reducing congestion and automobile dependence. He defines mobility as "the ability [of individuals] to engage in desired activities at moderate costs to themselves and to society."

Ewing cites two key implementation strategies for solving mobility problems. First, according to the author, the length, mode, and frequency of trips of household travel is affected by residential accessibility—the accessibility from a person's home to their destination; and by destination accessibility—the accessibility from one destination location to another. Better accessibility can be achieved, according to Ewing, through better land-use planning at the regional and community levels.

The second strategy espoused by the author is travel demand management

(TDM). TDM attempts to reduce the number of automobiles on the roads at peak travel times. This strategy promotes such techniques as carpooling, staggered work hours, compressed work weeks, and telecommuting. The success of TDM programs hinges on employers' willingness to implement them and to provide incentives to their employees to utilize them.

The author also examines how cities can create conditions favorable to transit, pedestrian, and bicycle use. He notes that to accomplish this goal, these modes must become more flexible and feasible. Again, Ewing concludes that land use development patterns must become more supportive of transit and alternative modes of travel.

In conclusion, Ewing calls for a paradigm shift in land use and transportation planning. He believes there "should be less emphasis on how fast vehicles move and more emphasis on how well people's travel needs are met."

Metro. 1994. *Region 2040 Recommended Alternative Decision Kit.* Portland, OR.

This analysis of alternative urban forms of growth for the Portland, Oregon metropolitan area shows that more concentrated development, in conjunction with expansion of transit service, reduces vehicle miles of travel and use of the automobile. This study uses one of the most advanced travel demand models in the United States to simulate transportation outcomes. It determines that under continued current development patterns, the urban area would have to expand by more than half of its current size over the next 50 years.

The study also tests three different scenarios that concentrate various amounts of growth in transit corridors, centers, and in neighboring cities. In the "Growing Out" scenario, a larger share of single-family housing is built than the region has at present, with more than one-fourth of future growth placed outside the current urban growth boundary. The "Growing Up" scenario keeps all future growth inside the urban growth boundary by increasing densities and building a larger share of multifamily housing. The "Neighboring Cities" scenario moves about one-third of the expected growth to other cities within commuting distance of the urban area. Not surprisingly, the highly concentrated development of the "Growing Up" scenario produces the highest transit use (6 percent of all trips) and the greatest reduction in VMT over base case levels (16.7 percent). The more dispersed patterns, while consuming more land, have lower levels of congestion.

Despite the results of this study, the ability to change travel behavior is limited, because much of the capital infrastructure that will serve the built environment for the next 50 years is already in place. Some of the study's other proposed changes in the way the regions develop may also not be feasible to undertake for political and economic reasons.

Mobility for the 21st Century Task Force. 1996b. *Strategic Goals for the 21st Century.* Washington, DC: American Public Transit Association.

In 1995, the American Public Transit Association formed the Task Force on Mobility for the 21st Century (M21). The M21 Task Force believes that the problems caused by urban sprawl are rapidly worsening. The Task Force

concluded that over the next fifty years, with continued existing development patterns, the nation will "slip into a downward spiral of economic, environmental, and social decline."

In response, the M21 Task Force engaged in a year-long strategic planning process to develop a plan for an alternative future. As a result, the Task Force devised four plausible scenarios for the future, developed a preferred vision for the year 2050, and adopted six goals and recommendations to make the vision a reality.

The four scenarios of how the Task Force believes urban development patterns may evolve over the next fifty years follow.

Boundless Sprawl—Continued growth and unchecked urban sprawl; U.S. maintains economic growth, but central cities decline and urban problems worsen.

Dying Cities—Continued growth and unchecked urban sprawl feed economic and social decline, causing a downward spiral. Central cities are faced with increased poverty, crime, and other problems.

Community-oriented Growth—Growth continues, but in the form of infill and mixed-use, pedestrian-scale communities centered around transit stations.

Reinventing the City—A new urban pattern emerges following the tenets of sustainable development. All development occurs within an urban growth boundary (surrounded by greenbelts), and every location can be reached easily by transit.

Based on the analysis of these plausible scenarios, the M21 Task Force developed a vision of their preferred future. This future, based on sustainable community development, benefits the economy, environment, social equity, community life, and individual quality of life.

In this vision, both central cities and suburbs thrive. Although people continue to live in suburbs, transit-oriented developments (TODs) have replaced low-density suburbs as the preferred neighborhood design. In addition, these neighborhoods allow easy pedestrian and bicycle movement. Also, TODs offer a wide choice of housing type, densities, and costs.

TODs offer numerous additional benefits. They require less new infrastructure and utilize existing infrastructure and maximum capacity, ease traffic congestion, save commuting time, and reduce pollution.

The Task Force acknowledges that the vision is a long stretch but believes that it is achievable if the following six strategic goals and recommendations are adopted.

1. Build on the principles of ISTEA.
2. Invest in innovative sustainable technologies.
3. Create desirable land-use and development patterns.
4. Strengthen regional and metropolitan planning and decision making.
5. Shift toward true cost pricing.
6. Provide creative leadership initiatives.

Empirical Studies

Cervero, Robert. 1991b. "Land Use and Travel at Suburban Activity Centers." *Transportation Quarterly* 45, 4: 479-491.

This article analyzes the effects of density, land-use mix, and parking characteristics on commuting behavior in suburban activity centers. The study uses data from

83 randomly selected buildings in six suburban activity centers, collected as part of a project called *Travel Characteristics of Large-Scale Suburban Activity Centers*, for the National Cooperative Highway Research Program.

The strongest relationship evidenced in the study was between density (measured as the height of each building) and transit use. Having retail operations in the building had only modest effects on mode choice; primarily it increased transit and walking mode shares. Parking supply had less effect on mode choice, probably because most of the office buildings had generous supplies of parking spaces.

Using buildings as the unit of analysis in this study poses some problems. For example, the study fails to consider other center characteristics that may play important roles in determining commuting behavior, such as distances between buildings and opportunities to shop and conduct personal business at other locations within the center.

Cervero, Robert, and Kara Kockelman. 1996. "Travel Demand and the 3Ds: Density, Diversity, and Design." ***Transportation Research Digest*** **2, 3:199-219.**

The authors claim that a host of urban design philosophies—new urbanism, transit-oriented development, traditional town planning—have gained popularity in recent years as ways of shaping travel demand. All share three common transportation objectives: (1) reduce the number of motorized trips; (2) of trips that are produced, increase the share that are non-motorized; and (3) of the motorized trips that are produced, reduce travel distances and increase vehicle occupancy levels. An expected outcome of weaning people from their cars, proponents hope, will be a lessening of the negative consequences of an automobile-oriented society—namely, air pollution, fossil fuel consumption, and class and social segregation.

Cervero and Kockelman describe how new urbanists, neo-traditionalists, and other reform-minded designers argue for changing three dimensions, or the 3Ds, of the built environment—*density, diversity, and design*—to achieve these objectives. While the effects of density on travel demand have been acknowledged, the effects of diversity and design have just as long been ignored. This paper examines the connection between the 3Ds of the built environment and travel demand. It tries to sort through the relative influences of these three dimensions after controlling for other variables, such as travelers' demographic characteristics. It does this by applying the technique of factor analysis to gauge the relative influence of each dimension as well as their collective impacts.

The research findings of this paper lend some degree of credibility to the claims of new urbanists and others that compact, mixed-use, pedestrian-friendly designs can reduce vehicle trips, vehicle miles traveled (VMT) per capita, and motorized travel. The research suggests that the effects of the Bay Area's built environment on travel demand were modest to moderate at best. Densities exerted the strongest influence on personal business trips. Additionally, residential neighborhoods that were spatially accessible to commercial activities, reflected by an accessibility index variable, tended to average appreciably less VMT per household. Diversity also had a modest impact on travel demand, although where it was significant, its influences was somewhat stronger than that of density. Having retail activities within neighborhoods was

most closely associated with mode choice for work trips. Further, the dimension of walking quality was generally moderately associated with travel demand. Finally, several specific design elements of the built environment seemed to be particularly relevant to non-work trip-making. Notably, neighborhoods with high shares of four-way intersections, as a proxy for grid-iron street patterns, and limited on-street parking abutting commercial establishments, tended to average less single-occupant vehicular travel for non-work purposes.

The researchers believe that higher densities, diverse land uses, and pedestrian-friendly designs must co-exist to a certain degree if meaningful transportation benefits are to accrue. Having nice sidewalks, attractive landscaping, and other pedestrian amenities in a low-density, residential-only neighborhood is unlikely to prompt many residents to walk to shops and stores. However, the synergy of the 3Ds in combination is likely to yield more appreciable impacts.

Dunphy, R. T., and K. M. Fisher. 1994. *Transportation, Congestion and Density: New Insights.* Paper presented at the 73rd Annual Meeting of the Transportation Research Board, Washington, DC: January.

Using data on urbanized areas from *Highway Statistics, 1990*, the authors investigate the relationships (using graphs) between density and vehicle miles of travel and travel use. They find some correlation between urbanized area population density and transit use (26 percent), but little correlation between vehicle miles of travel and density (8 percent). However, using data from the *1990 Nationwide Personal Transportation Survey*, the authors find that people in denser areas make nearly the same number of daily trips as people at lower densities, but they drive less. At most densities the average number of person trips per day is just below 4.0; only at 30,000 persons/square mile or more do trip numbers dip to 3.4 trips per day. However, the average number of trips by car drops from about 3.5 at densities below 30,000 persons/square mile to 1.9 at 30,000 persons/square mile. People living at higher densities drive less because both transit and walking/biking are more viable options. The authors, however, find a strong correlation between density and life cycle stage. They contend that demographics may be more of a contributing factor to differences in travel behavior than density.

This study is descriptive, suggesting relationships that need further analysis with multivariate techniques to sort out the relative effects of household characteristics versus land-use density. The data analyzed in this study are also aggregate, comparing whole regions rather than specific places within regions where people live and work.

Dzurik, Andrew. 1993. "Transportation Costs of Urban Sprawl: A Review of the Literature." *State Transportation Policy Initiative.* Center for Urban Transportation Research. November.

This article cites nine studies that deal with transportation costs and sprawl, including the classic RERC *The Costs of Sprawl* study (1974a), reviews by Altshuler (1977) and Windsor (1979), and several others. The first part of the article cites a 1965 study—"The Nature and Economics of Urban Sprawl" by Harvey and Clark—that defined three characteristics of sprawl, low-density, ribbon, and leapfrog development.

Automobile use was also viewed as the catalyst for urban sprawl. John Kain (1967) argued, however, that any savings from developing high-density areas may be offset by higher construction costs per unit.

RERC's report is cited extensively. It estimated that a low-density sprawl community would require more than six times the amount of minor streets than a planned high-density community. Only road length costs were considered as direct costs in the analysis of transportation variations among these communities. However, two indirect costs were also considered: travel time and air pollution. The RERC report assumed twice as much VMT in a low-density community, which accounted for a large difference in such costs.

Dzurik's article then cites Altshuler's criticisms of the RERC report. Altshuler's book *The Urban Transportation System* (1979) argues that the American public has strong preferences for auto transportation and low-density settlements. Therefore, Americans will refuse to live in densities high enough to bring about any changes in the problems associated with sprawl, which he believes have been exaggerated anyway. Bowler completed a study in 1977 that showed that "user-operated transportation" accounted for about one-seventh of consumer spending, a proportion that stayed roughly constant from 1950 through 1973. He argues that suburban living results in higher use of energy and land resources for transportation than higher-density living.

When the urban environment is modeled as polycentric, however, the percentage of suburban dwellers who increase their travel distances for journeys to work no longer continues to rise, since work places also become decentralized. Yet many models assume that rising commuting costs are a major transportation cost of suburbanization.

Gordon also argues that because work trips are declining as a percentage of all trips, the relative importance of accessibility to workplaces as a motive for choosing places to work and places to live is falling. Gordon and Richardson argue that decentralization is an antidote to traffic congestion because it scatters both origin and destination points and makes suburb-to-suburb trips shorter than any other types.

BART failed to replace the auto as the preferred means of commuting in the Bay Area, in spite of its enormous cost. Where light rail systems have been created, cities have experienced small gains in public transit ridership over pure bus systems, but they have also incurred major cost increases. Light rail tends to replace bus travel more than auto travel.

Dzurik reviews the argument over compact development. One advantage compact development is supposed to have over sprawl is that it uses the excess capacity in existing infrastructures, rather than create a need to build new infrastructures. This was a major source of the economies found in the New Jersey sprawl studies. But such savings do not always materialize.

Dzurik discusses how much subsidy from local governments goes into highways and mass transit. In Milwaukee, Wisconsin, for example, he points out, the local burden of highway costs equals 59 percent of the local property tax levy. Because user fees do not pay the entire cost of auto travel, more sprawl occurs than would otherwise take place.

Dzurik's study claims that the transportation costs associated with urban sprawl have not been studied in the appropriate quantitative terms. Therefore, most questions about this issue are still unanswered. His article cites unfavorable views of sprawl's transportation costs in 12 articles and studies, with one-sentence summaries of their major complaints.

Dzurik's article contains almost no original quantitative analysis. Numerous cited studies offer contradictory evidence, and the author does not critically analyze why these differences exist. Further, he offers few better approaches to research the areas of transportation and urban sprawl.

Frank, L. D., and Gary Pivo. 1994. *The Relationship Between Land Use and Travel Behavior in the Puget Sound Region.* WARD 351.1. Olympia, WA: Washington State Department of Transportation.

The authors use data from the *1989 Transportation Panel Survey* for the central Puget Sound region, along with household characteristics from the *1990 Census*, employment data from the state employment agency, and land-use data from the county assessor to identify the factors that affect travel behavior. They find that density, mix, and jobs/housing balance are all related to travel behavior, with employment density and jobs/housing balance having the strongest relationships. At higher densities, trips are shorter but take more time. More trips are made using alternatives to the single-occupant vehicle. As land-use mix increases, trip distances, times, and auto-mode shares decrease. As jobs and housing become more balanced, trip distances and travel times go down. The relationships between density and mode split are not linear. The authors identify thresholds at which there is a substantial increase in transit use. These thresholds are 50-75 employees and 9-13 persons per gross acre for work trips, and 75 employees and 18 persons per gross acre for shopping trips. The use of carpooling, however, seems unrelated to urban densities or other land-use attributes. The study controls for household characteristics, such as income and vehicle availability.

Gordon, Peter, A. Kumar, and Harry W. Richardson. 1989. "The Influence of Metropolitan Spatial Structure on Commuting Time." *Journal of Urban Economics,* 26: 138-151.

The authors combine data on residential and employment densities (residents or workers per acre of land zoned for that purpose) for 82 SMSAs from twelve states (from the U.S. Geological Survey LANDSAT file) with census data to identify factors that influence commuting times by auto and transit. Their research finds that lower residential densities are associated with shorter commuting times both by car and by transit. For auto trips, concentration of industrial employment leads to shorter travel times, whereas concentration of commercial employment increases trip times. The clustering of manufacturing produces economies in driving, but the clustering of commercial activities (such as in the CBD) produces congestion that reduces times. Other variables (land area, income, economic structure) have the expected positive or negative influences, and the equations are fairly robust, explaining 61 to 87 percent of the variability in mean travel times. As a result, the authors conclude that polycentric or dispersed spatial structures reduce commuting times.

The authors' use of SMSAs as the unit of analysis, however, raises questions about what density means. No SMSA has

uniform density throughout. Perhaps lower regional density is a proxy for age of development, city size, or some other factor that influences transit use.

Holtzclaw, J. 1990. *Explaining Urban Density and Transit Impacts on Auto Use.* Paper presented to the State of California Energy Resources Conservation and Development Commission by Natural Resources Defense Council and the Sierra Club. April 19.

Holtzclaw compares the annual vehicle miles of travel in five communities with various densities in the San Francisco Bay Area to test whether higher residential densities combined with better transit service and neighborhood shopping result in less driving. The study finds that doubling residential density reduces annual vehicle miles by 20 to 30 percent. Better transit access also reduces vehicle travel.

Holtzclaw's study, however, is a cross-sectional one, that only demonstrates correlation between density and vehicle miles of travel. It does not show, for example, that increasing density in a particular neighborhood would reduce vehicle miles of travel. Neither does the study control for income levels or other characteristics of households that influence vehicle miles of travel.

Holtzclaw, J. 1994. *Using Residential Patterns and Transit to Decrease Auto Dependence and Costs.* San Francisco, CA: Natural Resources Defense Council.

Holtzclaw uses smog check odometer readings for 28 communities in San Francisco, Los Angeles, San Diego, and Sacramento—all with at least 20,000 residents—to evaluate the relationship between density and land use. The study finds that neighborhood density is negatively related to both automobile ownership rates and vehicle miles of travel, controlling for household income and size. When household densities double, vehicle miles of travel decline by 16 percent, controlling for such factors as transit service intensities and vehicle ownership. Better access to transit also reduces vehicle miles of travel. Shopping opportunities and the pedestrian environment, on the other hand, are not statistically significant in explaining travel behavior.

Although, income is controlled in this study, residents could still vary by number of children, number of workers, or other characteristics that influence travel behavior.

While, this cross-sectional analysis shows a relationship between density and automotive use in existing communities, it does not demonstrate that if low-density communities became denser fewer trips would be made by automobile.

Newman, Peter W. G., and Jeffrey R. Kenworthy. 1989a. *Cities and Automobile Dependence: An International Sourcebook.* Brookfield, VT: Gower Publishing.

Newman and Kenworthy assemble a set of data on the transportation and land-use characteristics of ten large U.S. cities, five Australian, twelve Western Europe, three Asian, one Canadian, and one Russian city for the period 1950 to 1980. Using gasoline consumption per capita as the primary measure of automobile dependence (other measures such as transit mode share are highly correlated with this measure), they identify the relationship between automobile dependence and urban density. Low densities are associated with high

automobile dependence, and high densities with less dependence on the automobile. This relationship holds for regions as a whole, for inner areas (pre-World War II parts of the cities), and for outer areas. As a result, the authors conclude that more compact cities would reduce automobile use.

Reviewers, however, have questioned the validity of using gasoline consumption as the measure of automobile dependence, noting that many factors, such as gas prices and fleet characteristics, influence gasoline consumption. Newman and Kenworthy's analysis of automobile dependence also fails to make full use of the data collected, employing only a single variable—urban density—to explain automobile use, when other factors are clearly involved. As a result, the role of density may be overstated.

Parsons Brinckerhoff Quade and Douglas. 1996b. "Commuter and Light Rail Corridors: The Land Use Connection." In *Transit and Urban Form, Vol. 1.* Washington, DC: Transit Cooperative Research Program, Transportation Research Board. October.

This study updates the work of Pushkarev and Zupan (1982) by analyzing the effects of residential densities and CBD employment levels and densities on light rail and commuter rail boardings. The data are from eleven cities in the United States with a total of nineteen light rail lines and six cities with a total of fortyseven commuter rail lines. Boardings and transit service characteristic data were provided by transit agencies. Employment and population characteristics are from the *1990 Census.* The data are used to develop models of light rail and commuter rail boardings and costs. The empirical results are then used to estimate boardings and costs for hypothetical light rail and commuter rail corridors.

The study finds that residential densities have a significant influence on light rail boardings. A 10 percent increase in residential density within two miles of stations increases station area boardings by 5.9 percent, holding constant other factors affecting ridership, such as income. Residential densities matter less for commuter rail boardings. Commuter rail is a high fare mode of travel, and many of the high-income riders come from low-density suburban areas some distance from the city center.

Both the size and density of the CBD influence light rail ridership. A 10 percent increase in CBD employment density raises light rail boardings per station by about 4.0 percent, holding constant the number of CBD employees, the residential density of stations, and other factors affecting ridership. For commuter rail, a 10 percent increase in CBD employment densities increases station boardings outside the CBD by 7.1 percent.

The study concludes that light rail is most cost-effective and efficient in the cities with larger CBDs and denser corridors. Commuter rail works best with dense CBDs. Other factors within the control of transit agencies, such as the availability of feeder bus service and park-and-ride lots, also influence ridership and costs.

Pushkarev, B., and J. M. Zupan. 1977. *Public Transportation and Land Use Policy.* Bloomington, IN: Indiana University Press.

The authors estimate the effects of population density on transit use by employing areawide population densities and transit use data from 105 urbanized

areas. They show that population density explained 55 percent of the variation in transit use in 1960, and 66 percent in 1970.

The authors also estimate the effects of residential density, downtown floor space, and the presence or absence of rail transit for 27 urbanized areas. Using these factors increases the explanatory power of the equations, but the new variables are still less significant than residential density in explaining transit use. Pushkarev and Zupan attribute this result to greater variability in office floor space than in residential densities among the areas studied.

UNLIMITED OUTWARD EXTENSION

Davis, Judy. 1993. "The Commuting of Exurban Residents." *Urban Geography*, 14, 1: 7-29.

A comparison of the commuting times of workers who bought homes in the suburbs and those who bought homes in the exurbs of Portland, Oregon, shows that the average exurban home buyer has a commuting trip six to seven minutes longer than his counterpart in suburbia, controlling for occupation, income, and other household and job characteristics. The data is from a survey conducted by the author of about 750 households that bought and occupied homes in 1987.

Although some exurban households have commutes similar to those of suburban households, the average exurbanite appears to trade off longer travel times for more space, a rural environment, lower housing prices, a better place to raise children, or some combination of these factors. However, exurban residents seem to sort themselves out so that those who live close to the urban area have central city and suburban jobs, whereas those who live farthest out most likely work in exurban towns.

Parsons Brinckerhoff Quade & Douglas. 1997. "TCRP Project H-13A—Draft Report: Consequences of the Interstate Highway System for Transit." Washington, DC: Transit Cooperative Research Program, Transportation Research Board.

This report describes the intended and unintended consequences of the development of urban interstate highways for transit by examining four metropolitan areas in the United States, four selected cities in Germany, and one city in Canada. The report includes profiles of these communities, their transportation systems, and the positive and negative impacts of their transportation choices.

The authors gathered information from published articles, official plans, and interviews with officials and other knowledgeable people in each community. They also visited each site. Their goal was to understand the history of the development of the interstate highway system within the urbanized area and the interactions between high-speed limited-access roads and changes in the transit system and land-use patterns.

The case studies were selected to test two major hypotheses identified from the literature review: that the interstate highway program biased transportation investments in favor of high-speed limited-access highways that made automobile travel much more attractive than transit use; and that interstate highways facilitated the suburbanization of households and firms, producing a pattern of development that is difficult for public transit to serve.

The authors present evidence from these case studies that confirms that the development of the interstate highway system adversely affected public transit. The data show declines in transit ridership, increasing difficulty in maintaining transit service levels, and the decentralization and dispersion of households and jobs in case study regions with the highest use of interstate highways. Yet the authors correctly point out that transit was in decline well before the interstate system was operational, and other factors supported development in outlying areas, such as low property tax rates, inexpensive land, and the growth of competing local governments.

The authors couch their main findings within other significant influences in the decline of transit:

1) The magnitude and certainty of public funding has influenced modal investment choices. These choices, in turn, have affected regional travel.

2) Those cities whose citizens have shown a continuous commitment to, and investment in, high-quality transit service have strong urban centers and high transit use.

3) Strong, well-respected institutions build and operate transit systems in the regions where the impacts of highways on transit are low.

4) Active, well-organized citizen groups mitigated the impacts of highways by successfully opposing certain highway designs as well as highway construction itself.

5) The integration of transportation and land-use policies, plans, and projects has mitigated the impacts of automobile infrastructure.

6) In cities where highways' adverse impacts are fewest, public policies support the use of alternative modes of transportation.

7) In general, city centers with fewer freeways have experienced less adverse impacts from automobile travel.

SPATIAL SEGREGATION OF USES (LAND-USE MIX AND URBAN DESIGN)

Suburbs (Employment and Residential Areas)

1000 Friends of Oregon. 1996. *Making the Land Use, Transportation, Air Quality Connection (LUTRAQ): Analysis of Alternatives. Vol. 5.* Portland, OR. May.

This study compares auto-oriented versus transit-oriented alternatives of land use and transportation patterns in suburban Washington County, in the Portland, Oregon metropolitan area. Each alternative utilizes the same land area and has the same overall density.

In the auto-oriented alternatives, most new multifamily housing and jobs are at the urban fringe. The "no build" variation includes few transportation improvements, whereas the "highways" variation includes a bypass freeway and other highway improvements. With the transit-oriented alternatives, most new multifamily housing and jobs locate on vacant lands near transit routes. This alternative also takes into account transit investments, retrofitting of pedestrian improvements, selected highway improvements, and a demand management program that includes parking charges for work trips. The region's travel demand model, which was enhanced to increase its sensitivity to density and design, is

used to simulate the transportation outcomes in 2010 of each of the alternatives.

The study finds that the package of transit-oriented development and transportation improvements that focus on non-automotive modes generates the following effects within the study area:

- Reduces auto ownership rates by 5 percent from auto-oriented levels
- Reduces single-occupant auto use for work trips to 58 percent compared to 76 percent in auto-oriented alternatives
- More than doubles the share of work trips made by transit over auto-oriented alternatives (18.2 percent versus 8.8 percent)
- Reduces daily vehicle trips per household from 7.5 to 7.2 trips
- Reduces the delay over "no build" levels by more vehicle hours than highway building alternative (53 percent reduction versus 43 percent reduction)
- Reduces peak period vehicle hours of travel at three times the rate that the "highway" building alternative does (15.7 percent reduction versus 5.6 percent)
- Reduces daily vehicle miles of travel by 6.4 percent, whereas the "highway" building alternative increases them by 1.6 percent.

One caveat, however, is important to note. The study area encompasses the fastest growing part of the Portland metropolitan area. The impacts would likely be less if transit-oriented land uses and transportation improvements were built throughout the metropolitan area, since the remainder of the region has less growth to focus toward transit-oriented developments.

Activity Centers

Cambridge Systematics. 1994. *The Effects of Land Use and Travel Demand Strategies on Commuting Behavior.* Washington, DC: U.S. Department of Transportation, Federal Highway Administration.

This study tests the influence of employment site design characteristics on commuting mode choice at suburban work sites in the Los Angeles area. The research involved on-site data collection of specific urban design and land-use attributes to ensure a careful calibration of the independent variables. The results indicate that the presence of land-use mix and certain urban design features, such as shade trees and sidewalks, in coordination with demand management programs, are responsible for increasing the percentage of work trips made by transit by three to four percentage points. An attractive urban environment proved to be the only factor that influenced mode choice in the absence of a travel demand program. In other words, mixed uses and access to services within the employment center were not strong enough incentives, by themselves, to generate more commuting by transit. This study did not control for factors such as the level of transit service to the site, however.

Cervero, Robert. 1989. *America's Suburban Activity Centers: The Land Use–Transportation Link.* Boston: Unwin-Hyman.

Cervero compares the commuting characteristics of workers in 57 suburban employment centers. These centers all have at least one million square feet of office space, 2,000 or more workers, and are at least five miles distant from the CBD. He uses cluster analysis to identify six types of centers—office park, office

center, large mixed-use center, moderate mixed-use center, sub-city, and large corridor. Cervero then uses analysis of variance techniques to determine whether the center types differ in commuting characteristics. He concludes that locations of higher densities and greater land use mix do result in more commuting by transit, ridesharing, and walking. Ridesharing is greatest in the centers with higher densities, whereas walking is greatest in centers with significant retail activity and nearby multifamily housing. These denser, more mixed centers also have slower speeds of travel because of greater congestion within the centers. This study did not control for transit availability and the quality of the pedestrian environment, however.

Cervero, Robert. 1996. "Jobs-Housing Balance Revisited." ***Journal of the American Planning Association*** **62, 4: 492-511.**

Using data from the 1980 and 1990 Censuses, Cervero compares the jobs-housing balance of the 23 largest cities in the San Francisco Bay Area. His evidence shows that the jobs-housing balance generally improved during the decade, particularly as jobs increased in formerly housing-rich areas. However, housing did not grow significantly in job-rich areas, largely because zoning and growth controls prevented housing growth. Fifteen of the communities studied showed small increases in the ratio of internal commuting to external commuting. Nonetheless, about twice as many people commuted in and out of the average community as commuted within it. Thus, he concludes that despite less segregation of uses (measured at a gross city-wide scale), many people continue to commute considerable distances in part because of mismatches between the jobs available in their community and the type of housing found there.

Among other things, this descriptive study demonstrates that the transportation consequences of spatial segregation of uses need more careful consideration than just a look at the numbers of residences and jobs. The mismatches between the incomes of employees and housing prices and between new jobs and housing availability also must be considered.

Neighborhoods

Cervero, Robert, and R. Gorham. 1995. "Commuting in Transit Versus Automobile Neighborhoods." ***Journal of the American Planning Association*** **61 2: 210-225.**

This study compares work trip mode shares and trip generation rates between matched pairs of transit-oriented and auto-oriented neighborhoods. Seven of the pairs are located in the San Francisco Bay Area, and six in the Los Angeles area. Transit-oriented neighborhoods are defined as those built around streetcars or rail stations prior to 1945, which have a grid street pattern. Auto-oriented neighborhoods are those built after 1945, with little orientation to transit, and with more curving streets and cul-de-sacs.

The neighborhood pairs in the study had similar incomes and, as far as possible, similar levels of transit service. Six of the seven San Francisco pairs showed the expected results of lower auto ownership and more use of transit and walking for work trips. (In one pair with a large university in the transit neighborhood, the transit neighborhood had less incidence of driving alone but walking often substituted for transit.) The difference in the share of drive-alone rates between neighborhood pairs ranged from 2.0 to

17.5 percent of trips. The results were more mixed in Los Angeles than in San Francisco, however.

The authors conclude that neighborhood design matters little in the Los Angeles area because of the overwhelming dominance of the automobile in this region. The results may also be muddled because transit service levels were less closely matched in the Los Angeles pairs than they were in the San Francisco pairs.

Ewing, Reid, P. Haliyur, and G. W. Page. 1994. "Getting Around a Traditional City, a Suburban PUD, and Everything In-Between." ***Transportation Research Record*** **1466: 53-62.**

In this study, the authors compare six communities in Palm Beach County, Florida, on the basis of work accessibility, neighborhood shopping opportunities, and pedestrian accessibility. They find little evidence that accessibility to retail affects mode choice or vehicle hours of travel per person. The shortest shopping and recreational trips occurred in a classic 1970s planned-unit development (i.e., a suburban auto-oriented community) because ample stores and recreational facilities could be found within the community. This result suggests that the mix of uses is as important as the layout of streets and other design features in determining travel behavior.

Handy, S. 1992. "Regional Versus Local Accessibility: Neo-Traditional Development and Its Implications for Non-Work Travel." ***Built Environment*** **18, 4: 253-267.**

Handy compares the shopping trip travel modes of residents of traditional and suburban neighborhoods in the San Francisco Bay Area. She finds that residents of traditional neighborhoods, where shopping opportunities are located nearby, make 2.75 to 5.5 times as many shopping trips by walking as residents of more auto-oriented neighborhoods. Residents of both types of neighborhoods make about the same number of auto trips to regional shopping malls, suggesting that neighborhood shopping trips may supplement rather than replace longer trips.

Handy, S. 1995. ***Understanding the Link Between Urban Form and Travel Behavior.*** **Paper presented at the 74th Annual Meeting of the Transportation Research Board, Washington, DC. January.**

In this study, Handy makes detailed comparisons of non-work trips in four suburban neighborhoods in the San Francisco Bay Area. A "traditional" and a "typical" suburban neighborhood are identified in Silicon Valley, where there are good transit connections to the rest of the region. Another pair is selected in Santa Rosa, on the fringe of the metropolitan area. The data used stem from original surveys. An analysis of variance shows that differences in travel behavior do occur because of urban form, controlling for household type (i.e., number of adults and number of workers). People make more shopping trips on foot in the "traditional" neighborhoods where the downtowns are connected to residential neighborhoods and offer services to those residents. It is not clear whether these trips replace auto trips, or merely supplement them, however. What is clear, is that people value choices and on average visit more than one grocery store and more than one regional mall in a month, if the choices are available. Having choice adds to

travel since trips are made to places more distant from home.

Kitamura, R., P. L. Mokhtarian, and L. Laidet. 1994. *A Micro-Analysis of Land Use and Travel in Five Neighborhoods in the San Francisco Bay Area.* Institute of Transportation Studies, University of California, Davis. November.

The authors studied the travel behavior of several hundred families in five San Francisco Bay Area neighborhoods. The areas were selected because they had similar median incomes. But some had high density, some low, and they varied in mix of use and access to rail transit. Three-day travel diaries were collected, and site surveys were made to identify urban design characteristics. Models estimated individual travel behavior and, therefore, controlled for individual characteristics such as income, occupation, education, and vehicle ownership. Differences in travel were explained both by individual characteristics and by land-use measures, especially residential density, public transit accessibility, and the presence of sidewalks. Density was most important in explaining the share of non-motorized trips. Access to transit influenced the number of non-motorized trips and the share of transit trips. The mix of uses was not a very powerful indicator of travel behavior, but a dummy variable for place (combining all the land use attributes) was significant.

Overall, however, the models developed in this study had limited explanatory power; they were able to explain only about 15 percent of the variability in the number or share of trips by various modes.

Parsons Brinckerhoff Quade and Douglas. 1996c. "Influence of Land Use Mix and Neighborhood Design on Transit Demand." Unpublished report for TCRP H-1 Project. Washington, DC: Transit Cooperative Research Program, Transportation Research Board. March.

In this report, separate studies examine the effects of neighborhood land-use mix and urban design on the demand for transit and other alternatives to the automobile.

The first study uses *Annual Housing Survey* data for 1985 for 11 large metropolitan areas to compare mode choices for work trips of residents in areas with and without easy access to a "corner store" or other commercial activities. A second study of the greater Chicago area uses transit and land-use data to identify the factors that influence individual transit trips. The third study compares the mode choices for work and non-work trips in "traditional" and "suburban" neighborhoods in the San Francisco Bay Area, using original survey data. All of the studies use multi-linear regression techniques to control for income and other household characteristics.

Overall, the studies show that the types and mix of land uses do influence the demand for transit, as well as the use of non-motorized modes. People who live in mixed-used neighborhoods have a lower probability of commuting by car (3 to 4 percentage points), a slightly higher probability of using transit (1 to 2 percentage points), and a much higher probability of walking or bicycling (10 to 15 percentage points) for work trips. In the Chicago area, a 10 percent increase in residential density is associated with an 11 percent increase in the number of trips by transit. Residents of "traditional" neighborhoods in San Francisco are more

likely to use non-automotive modes for non-work trips than residents of "suburban" neighborhoods. The neighborhood comparison study, however, did not find statistically significant differences in mode choice for work trips between the two types of neighborhoods.

Moreover, all these studies found it difficult to sort out the effects of land-use mix and urban design, because these characteristics are so strongly correlated with density. When density is included in an equation, mix and design variables generally explain little about mode choice. Each of the studies controlled for residential characteristics such as income and auto ownership. Because the studies are cross-sectional, however, they show only correlation between land-use characteristics and mode choice, not causality.

DISPERSED EMPLOYMENT

Cervero, Robert; Timothy Rood; and Bruce Appleyard. 1997. "Job Accessibility as a Performance Indicator: An Analysis of Trends and their Social Policy Implications in the San Francisco Bay Area." Institute for Urban Regional Development, University of California at Berkeley.

The authors claim that "accessibility," as an indicator of opportunities to reach destinations efficiently, has gained increasing attention as a complement to transportation planning's more traditional mobility-based measures of performance, like "average delays" and "levels of service." They maintain that evaluating transportation performance in terms of accessibility allows a more balanced approach to transportation analysis and problem-solving.

Increasing accessibility by bringing urban activities closer together through more compact development and the inter-mix of land uses, as well as by promoting teletravel, can substitute for physical movements. Although not a replacement for mobility-based planning, accessibility measures help gauge progress toward meeting other regional objectives like sustainability and social equality.

The authors use census transportation planning data to study trends in job accessibility between 1980 and 1990, with the San Francisco Bay Area serving as a case context. The objectives of the analysis are multifold: 1) The work seeks to advance the use of accessibility indicators as inputs to long-range transportation planning and monitoring; 2) The work aims to enrich how job accessibility is measured by introducing an "occupational match" refinement; 3) The authors employ empirical measures of job accessibility to address the spatial mismatch question; and 4) The work calls for more formally institutionalizing and expanding the use of accessibility indicators for evaluating and monitoring long-term transportation system performance as well as progress toward achieving broader social welfare objectives.

The research showed that the Bay Area's largely market-driven patterns of regional employment growth failed to improve job accessibility among residents of the region's poorest inner-city neighborhoods. Minority neighborhoods in the inner East Bay and parts of downtown San Francisco averaged the worst occupational mismatches in terms of proximity to available jobs throughout the 1980s. Controlling for occupationally matched accessibility, educational levels, and vehicle availability, Bay Area neighborhoods with high shares of African Americans still had

disproportionately high unemployment rates in 1990.

Cervero, Robert and Kang-Li Wu. 1996. "Subcentering and Commuting: Evidence from the San Francisco Bay Area, 1980-1990." Paper presented at the 1996 TRED Conference on Transportation and Land Use. Cambridge, MA: Lincoln Institute. October.

This paper examines the growth of dispersed subcenters in the San Francisco Bay Area and the effects of this growth on commuting. Cervero identifies 22 employment centers with 7 or more workers per gross acre and 9,500 or more employees in 1990. Downtown San Francisco is the largest and most densely populated subcenter. Other centers are in Silicon Valley and the East Bay core area (Oakland, Berkeley, and Emeryville); 16 more are located further out in suburbs. Two of the subcenters did not exist in 1980. Employment in these subcenters grew on average by 23.6 percent annually in the 1990s, increasing the regional share of employment in centers from 47.5 percent to 48.2 percent.

The growth of these subcenters has produced an increase in vehicle miles of travel (VMT) for commuting trips. On average, one-way VMT increased from 7.1 to 8.7 miles during the 1980s—a 23 percent increase, with the largest increases to be found in suburban centers. This increase in vehicle miles of travel is linked to both longer distances and to greater use of single-occupant vehicles. Of these, longer distances between home and work had more influence on VMT, since outside of downtown San Francisco and the eastern Bay Area, the vast majority of commuters used cars in both 1980 and 1990. Cervero estimates that more than four-fifths of the growth in VMT is due to longer distances between home and work. Longer distances were especially important in increasing VMT in the more peripheral centers.

While at least one of their previous studies suggested that job decentralization shortened commutes, this result has been explained mainly in terms of recorded travel times, and typically measured at the aggregate, metropolitan-wide level. This study sought to refine the analysis of spatial implications on commuting by disaggregating data among employment centers, measuring highway and transit network distances, and examining commuting behavior during the 1980-1990 window of rapid suburban employment growth. When combining refined commute distance measures with data on shifts in modal distributions and occupancy levels, the finding is that employment decentralization is associated with substantial *increases* in commute VMT per employee. Cervero attributes these longer distances both to regional growth and to mismatches in the job and housing markets that necessitate long commutes.

THE COSTS OF TRAVEL

Apogee Research, Inc. 1994. *The Costs of Transportation: Final Report.* Conservation Law Foundation. March.

This report reviews the literature on the costs of transportation and estimates the per-mile costs of several modes for Boston, Massachusetts, and Portland, Maine. The study divides costs into three types: user costs, governmental costs, and societal costs. Extensive data were collected for the case study regions, in an effort to accurately reflect the cost of travel in these specific places. Some costs—land loss, water pollution, solid and hazardous waste pollution, and social

isolation—could not be quantified and are not included in the analysis.

The report estimates costs for various modes, in different kinds of environments. For example, it estimates that a peak-period trip in a dense part of Boston using a single-occupant vehicle (SOV) on an expressway costs $1.05 per mile. Of the $1.05, $0.88 are user costs (including $0.24 for travel time), $0.05 are governmental costs not paid by the user, and $0.12 can be regarded as societal costs. In the off-peak period, the same trip costs $0.89 per mile, with $0.73 attributable to user costs ($0.10 for travel time), $0.05 to governmental costs, and $0.11 to societal costs. In a low-density setting the peak and off-peak SOV trips both cost $0.71. For the SOV mode, user costs, including travel time, vary the most among different settings.

By contrast, a high-occupancy vehicle (HOV) expressway trip in high-density Boston at peak hours costs $0.58 per mile, a commuter rail trip $0.58, a rail transit trip $1.04, a bus trip $1.09, a bicycle trip $0.73, and a walking trip $2.56. The relatively higher cost of rail transit, bus, and walking trips is primarily attributable to the added travel time. Costs in the smaller city of Portland are generally lower for all modes and densities.

The authors believe that transportation does influence sprawl, and this impact should be considered a societal cost of the transportation system. They do not, however, measure this cost, since studies have neither identified the full range of the costs of sprawl nor the proportion of these costs that are due to the transportation system.

This report documents the ways that travel costs differ with the physical environment and the modes available. As far as possible, costs are based on actual data for the locations studied, although measures of societal costs are generally taken from national studies.

DeCorla-Souza, Patrick; Rathi, Ajay K.; and Caldwell. 1992. "Nationwide Investment Requirements for New Urban Highway Capacity Under Alternative Scenarios," *Transportation Research Record 1359*: 57-67.

The paper provides cost estimates for maintaining the nation's urban highway capacity at 1985 levels of service through the year 2005. Besides providing the capital costs as a function of various levels of travel growth projections, the authors add a policy dimension to their estimates. Both land-use and transportation systems management policy constraints are included. While significant costs will be required despite policy levels, the paper demonstrates that appropriate policies could contain the capital investments required.

The cost models were run under the condition of no additional management imposed, then under moderate and high management conditions. The policy constraints incorporated were complex, containing several thrusts each in the land-use and traffic management areas.

Land use policies involved restricting development to where existing capacity was available, incentives for high density developments at commute trip terminus areas, mixed-use developments in the suburbs, and traditional neighborhood developments. On the transportation management side, policies included encouraging alternative commuting modes, work rescheduling programs, discouraging solo commuting, and increasing traffic control provisions.

The paper describes the process used in the analysis. There are two phases to the procedure: first to calculate the additional lane-miles required, then to calculate the equivalent dollars needed. The analysis yielded lane-mile increases ranging from 33 percent (low growth) to 49 percent (high growth) under baseline policy conditions. For the high management condition, the range was from 22 percent to 34 percent. At the low-growth condition which the authors thought was the more likely, policy management cut the required increase by a third. It should further be noted that with the elevated policy management, the high-growth condition almost equaled that of low growth and policy status quo condition. The capital investment needs varied from 1.2 trillion dollars under the high-growth, baseline management conditions down to 375 billion dollars under the low-growth, high management scenario.

The authors conclude that significant increases in highway funding (up to a possible 1.2 trillion dollars) will be required to maintain the 1985 levels of services. With the imposition of only a moderate increase in management policy and under the assumption of a low underlying travel growth rate, the required investment can be halved.

Delucchi, M. A. 1996. ***The Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991: Summary of Theory, Data, Methods, and Results.*** **Davis, CA: Institute of Transportation Studies. August.**

In this 20-volume study, Delucchi and his colleagues estimate the total social cost of automobile use in the United States for 1991. The study shows that many cost functions are non-linear and dependent upon location. Therefore, the study's estimates cannot be divided by total automobile mileage or some other measure of use to produce an accurate average price to use in other studies or analyses, although the methods may be applied in other studies.

Delucchi divides costs into six categories:

1) personal non-monetary costs, such as travel time;
2) motor vehicle goods and services priced in the private sector, such as vehicle ownership, maintenance, and use costs;
3) motor vehicle goods and services bundled with other goods and services in the private sector, such as employer- or business-provided parking;
4) publicly provided motor vehicle goods and services, such as roads;
5) monetary externalities of motorvehicle use, such as accident costs not paid by the responsible party; and
6) nonmonetary externalities of motor vehicle use, such as air pollution and global warming.

This report estimates that the total social cost of motor vehicle use is between $1.88 trillion and $2.839 trillion per year. Of these costs, 38 to 50 percent of the costs are for private-sector goods and services; 21 to 22 percent of the costs are for personal non-monetary purposes; 13 to 21 percent are for non-monetary externalities; 4 to 5 percent are for monetary externalities; 4 to 8 percent are for bundled private-sector costs; and about 7 percent are for public infrastructure and services. Delucchi also estimates that payments by motor vehicle users total $109 billion to $173 billion dollars a year, which is less than the $125 to $207 billion estimate of the amount spent on public infrastructure and services. He argues, however, that it is not necessary for user payments to match government expenditures for efficient

provision of resources. The difference between taxes paid by users and the provision of public goods and services related to motor-vehicle use must be judged on other grounds.

Delucchi does not include urban sprawl as a cost of automobile use. He argues that sprawl is a result of locational decisions, not motor vehicle use. Although transportation systems and costs may influence location decisions, he contends that the costs of different patterns of development are not directly a result of the use of motor vehicles. Furthermore, he claims the proper corrective action is to charge correctly for infrastructure provisions and other aspects of urban form, not to change automobile prices.

Ewing, Reid. 1997. "Is Los Angeles-Style Sprawl Desirable?" ***and*** **Gordon, Peter and Harry W. Richardson. 1997a. "Are Compact Cities a Desirable Planning Goal?"** ***Journal of the American Planning Association*** **63, 1 (winter): 107-126.**

These two articles published in the *American Planning Association Journal* debate the sprawl issue. The first article by Reid Ewing paints sprawl as undesirable. It defines sprawl not as suburbanization per se but rather as a wasteful form of outward development. Sprawl is characterized by: 1) leapfrog or scattered development; 2) commercial strip development; or 3) large expanses of low-density or single-use development. Ewing points out two indicators that typify sprawl—suburban environments that are *difficult to access* and those that *lack functional open space.* Locations that are difficult to access are those far from the core and from each other; locations that lack functional open space are defined as those where open space is totally private and cannot be used to link neighborhoods, buffer incompatible uses, or provide space for social interaction, recreation or civic functions.

According to Ewing, sprawl is reinforced by consumer preference, technological innovation, public transportation subsidies, and the "more than shelter" concept of the housing market.

Costs of sprawl include increased: 1) vehicle miles traveled; 2) energy consumed; 3) public/private infrastructure; 4) depletion of developable and fragile lands; and 5) psychic and social stress. The cures for sprawl include more government oversight in the form of state and regional planning and more compact, mixed-use cluster development.

The second article by Peter Gordon and Harry W. Richardson attempts to attack "compact cities" as an alternative to spread-out metropolitan development—or sprawl. Gordon and Richardson define compact cities as those with 1) high densities at a macro or metropolitan level; 2) even higher densities at a micro or neighborhood/community level; or 3) even higher densities at a downtown or central city level. Gordon and Richardson reject compact cities because: 1) people like low, rather than high-density living; 2) there is no real chance that at either a national or global level there will be a shortage of land; 3) there is currently an energy glut, and therefore no need to alter residential preferences to conserve fuel; 4) the automobile is the most efficient and preferred way to access residential neighborhoods, and ideally suited to spread development; 5) suburbs are not congested and by their location have contributed to less inner-city and inner-suburb congestion; 6) inner city (compact) and suburban (spread) work and shopping trips are compatible; 7)

agglomeration economies, once the province of cities, have now moved to suburbs; and 8) central locations have no market and continue to decline, and their rescue is a wasteful misallocation of public funds. Given these reasons, no case can be made for compactness as a description of desired urban form.

Which article is right? The answer is probably both. People appear to 1) prefer the accroutrements of suburban living but dislike strip commercial development; 2) want to distance themselves from urban problems, but worry about energy and land consumption; 3) like their automobiles but see merit in transit; 4) see a growing sophistication in suburbs but acknowledge a need for safe and functioning cities; and 5) travel and function in an environment that is less than efficient and less than beautiful, but very, very comfortable.

Hanson, M. E. 1992. "Automobile Subsidies and Land Use: Estimates and Policy Responses." ***Journal of the American Planning Association*** **58, 1: 60-71.**

This paper estimates the subsidies of automobile use in Madison, Wisconsin, a medium-sized city, in 1983. Hanson uses data on highway costs and taxes in the city and determines that direct subsidies for highway infrastructure, maintenance, and policing were equivalent to $0.024 per passenger-mile or $105 per person in 1983. Indirect subsidies for air and water pollution, petroleum prices, land-use opportunity costs, and personal injury were estimated from national data, and are, therefore, less precise than the highway data. Nonetheless, he calculates that indirect subsidies were equal to $0.034 per passenger-mile or $257 per person. In this estimation of costs, the largest subsidies were for personal injury (36 percent), highways (23 percent), and air pollution (15 percent).

Hanson contends that subsidization of the automobile produces more dispersed patterns of development than would occur otherwise. Furthermore, he claims that sprawled development limits transportation options by making the automobile the only viable source of travel.

Litman, Todd. 1995. ***Transportation Cost Analysis: Techniques, Estimates and Implications.*** **Victoria, BC: Victoria Transport Policy Institute. February.**

Based on a review of existing studies, Litman estimates the cost per mile for a number of different modes of transportation: average car, fuel-efficient car, electric car, van, rideshare passenger, diesel bus, electric bus/trolley, motorcycle, bicycle, walking, and telecommuting. The report includes cost estimates for 20 different factors that affect travel choice, ranging from the costs of operating a vehicle to the cost of lack of transportation options.

Litman estimates that for urban travel during peak periods, a mile of travel by automobile costs $1.33. Of this amount, $0.16 is attributable to variable vehicle costs, $0.25 to fixed vehicle costs, $0.31 to user time and risk, and $0.61 to external or societal costs, such as pollution and land use impacts. The same mile of travel in an urban area during the off-peak hours costs $1.06, with $0.14 attributable to various vehicle costs, $0.25 to fixed vehicle costs, $0.33 to user time and risk, and $0.34 to external or social costs.

Litman does not separate out governmental costs of travel. Those costs paid by users, such as roads built with gasoline

taxes, are considered user costs; those paid through general taxes, such as policing, are lumped in external costs. The largest external costs in Litman's scheme are for air pollution, accident costs not paid by the user, the opportunity costs of land currently used for roads, and external costs of energy consumption such as tax subsidies, energy security, and environmental damage.

Litman contends that land-use costs are a legitimate cost of automobile use because auto use encourages sprawl. It requires large amounts of land for transportation facilities and makes development of the urban fringe much easier. The effects include loss of prime farmland and wetlands, aesthetic degradation, loss of community, and higher transportation costs. Indeed, Litman estimates that landuse effects cost about 7 cents per mile, compared to 33 to 35 cents per mile for owning and operating the vehicle and 17 to 23 cents for travel time.

This study provides relative measures of the various costs of using the automobile versus other modes of travel; the calculations are based on estimates made by others. The data used rarely cover the full range of modes for which the author estimates costs. Thus, the figures in his tables are often simplified. The author attempts to monetize all costs despite the lack of hard data on many costs. The numbers are average estimates and do not consider location-specific factors such as differences in costs for urban and rural road building or congestion. The types of outcomes that the author counts as land-use impacts of transportation are generally counted elsewhere in an analysis of the costs of the sprawl and should not be counted again.

MacKenzie, J. J., R. C. Dower, and D. D. T. Chen. 1992. *The Going Rate: What It Really Costs to Drive.* Washington, DC: World Resources Institute.

This report estimates the amount spent on automobile subsidization in the United States; it defines subsidies as costs not paid directly by the user. According to the study, road users pay only about 60 percent of the $53.3 billion annual governmental costs of building and maintaining roads. They pay only 25 percent of the $91.0 billion police, fire, and other municipal costs associated with automobile use. Free employer-provided parking accounts for the largest portion of the subsidy. The authors estimate that 85 percent of the $100 billion cost of employee parking is not paid by the user. The report also estimates that users pay virtually none of the air pollution costs (estimated to be $37 billion), security costs for maintaining a reliable supply of oil ($25 billion), petroleum subsidy ($0.3 billion), or noise pollution costs ($9 billion). About 15 percent of accident costs, or $55 billion worth, are also estimated to be paid by someone other than the responsible party. The authors were unable to estimate some costs, however, such as the opportunity costs of land devoted to roads.

Estimates are based on data from previous studies. Estimates of externality costs are more speculative than other costs.

Parsons Brinckerhoff Quade and Douglas. 1996a. *Cost of Travel in Boulder.* City of Boulder, CO. July 15.

This study employs the methods of the Apogee study; local data for governmental costs; and national data for societal costs; and local and national data for user costs to estimate the total cost of typical

trips by various modes within the built environment of Boulder. The study is based on actual travel times to and from specific locations.

The authors estimate that the cost of commuting to Denver (25.5 miles) is $24.61 by single-occupancy vehicle (SOV) and $15.79 by transit. The SOV trips breaks down as follow: $19.40 for user costs (mostly travel time); $1.16 for governmental costs; and $4.04 for societal costs. The transit trip includes $10.68 for user costs; $4.70 for governmental costs (mostly for transit provision), and $0.41 for societal costs. Although, in this case, transit is a cheaper trip, for a multi-purpose shopping trip of 9.75 miles within the city of Boulder, an SOV trip costs much less than a transit trip, $11.66 versus $29.17. Transit is more expensive because of the time involved and because of the relatively high governmental expenses for off-peak transit travel. For a short 2-mile trip to downtown Boulder, more options are considered. An SOV trip costs $4.02, a transit trip $3.43, a bike trip $1.74, and a pedestrian trip $5.59. The relatively high costs of pedestrian travel is due to the longer time needed to complete the trip.

This study shows that travel costs vary with the environment and by type of travel. Transit costs less for long commutes; walking and bicycling are viable alternatives for short trips in a compact city; the car is best for linked trips.

Voorhees, M. T. 1992. *The True Costs of the Automobile to Society.* City of Boulder, CO. January.

This study estimates the total annual cost of automobile use in the United States in 1990. The author divides costs into two main categories: 1) the direct expenses of automobile ownership and use, including the cost of highways; and 2) external costs, including direct monetary costs, for emergency medical care; lost economic gain due to air pollution and other externalities; and the opportunity costs of using land for roads and parking. Relying on data from other studies, he estimates that in 1990, the total cost of automobile use in the U.S. was $1.152 trillion. The largest costs were direct expenditures for automobile ownership and use ($440 billion, or 38 percent); land-use opportunity costs ($246 billion, or 21 percent); congestion costs ($146 billion, or 13 percent); air pollution costs ($100 billion, or 9 percent); and highway costs ($80 billion, or 7 percent). Voorhees also argues that the automobile has two major land-use impacts; it consumes large amounts of land for roads and parking and it encourages sprawl. He does not try to estimate the costs of sprawl, however, because he lacks data and because these costs are already calculated in the amount of fuel consumed and other costs of using the automobile that result from a more dispersed pattern of development.

His external cost estimates are quite subjective and would easily be changed by making different assumptions. The cost estimate for land opportunity costs is relatively large compared to estimates in other studies.