THE FULL SOCIAL COSTS OF ALTERNATIVE LAND USE PATTERNS: THEORY, DATA, METHODS AND RECOMMENDATIONS

Prepared for

U.S. Department of Transportation
Federal Highway Administration

Parsons Brinckerhoff Quade & Douglas, Inc.
ECONorthwest

June, 1998

NOTICE

TABLE OF CONTENTS

LIST OF FIGURES

SUMMARY: THE FULL COSTS OF ALTERNATIVE LAND USE PATTERNS

A FRAMEWORK FOR EVALUATION

Regional transportation and land use planners' get to general goals without much difficulty. Where they have problems is in the plan evaluation stage. They lack a framework for thinking about the impacts of policies.

Chapter 2 of this report focuses on developing such a framework, one that is comprehensive (all significant benefits and costs are counted) and mutually exclusive (they are counted only once). It addresses such questions as: What are the impacts (benefits and costs) of alternative urban forms? What are the causal relationships among those impacts, including how public goals and policies about urban form interact with market forces?

Many of the costs of different urban forms can be measured by adding up the market costs of the resources the different forms of development use up. Supplying sewer and water to new residential development takes labor (planning, design, construction), concrete, steel, machinery and so on. The costs can be added and expressed in dollars. Many of the benefits and costs of public projects, however, are ones not typically registered through market transactions. Some of these benefits and costs are not internalized in the prices paid for the goods and services needed to build and operate the project - for example, the costs of air pollution on people and property near highways where automobiles generate that pollution. Economists call such costs spill-overs or externalities, and argue that society should consider them in its evaluation of a project since they result in real gains or losses.

Without an acquaintance with the fundamental concepts and methodological issues associated with a full-cost framework, planners and policymakers will be unable to take the first steps towards a more comprehensive evaluation of alternative urban forms, and the policies and investments that cause them to occur. Some of the main concepts and issues explored in this report include the following:

- *Costs are real economic resources used by a policy or project.*
- *Benefits are negative costs; costs are negative benefits*.
- *Benefits and costs must be defined in a way that is both comprehensive and mutually exclusive*.
- *Measuring all benefits and costs means considering some that do not have obvious market prices.*
- *A full-cost accounting framework must look at all impacts, both benefits and costs, that result from a defined change in the state of the world (in the case of this study, either a change in urban form or, more correctly, from a change in policy that attempts to change urban form).*
- *A full-cost accounting framework must consider all the people affected by the change. Many people may feel the change not just as residential consumers, but also in their capacities as employees of businesses and government.*

These points lead to a framework like that shown in Figure S-1 as being most useful pictorially as a descriptor of the framework required for analyzing the impacts of alternative development patterns.

Figure S-1 shows our hypothesis that the main effects of a change in form should be captured through changes in the costs of providing infrastructure services. As the title of Figure S-1 implies, an important and defensible assumption is that the effect of urban form on households, businesses, and governments occurs mainly through a derived demand for infrastructure, an intermediate good.

Our conclusion is that the impact of changes in urban form on the cost of infrastructure is probably the single most important impact to evaluate. That approach, with infrastructure as the sole concern, does not cover everything, either technically or politically. However, as a reasonable basis for an accounting framework, Figure S-1 is appropriate and useful.

THE STATE OF KNOWLEDGE

Much of the literature on the impacts of alternative development patterns has been cast in terms of the impacts of "sprawl." We use sprawl as a heading under which we can organize and review a variety of published literatures on the impacts of development. Sprawl is by no means the only possible settlement pattern, though it is, following the definition we have just given, a nearly ubiquitous one. Because sprawl is commonly defined in terms to which most people can relate, and it is widely evident, it serves as a convenient organizing principle under which we will conduct this literature review.

Various commentators have attributed over two dozen negative and over one dozen positive impacts to alternative development patterns. These impacts are set forth in Figure S-2, and explored in Chapter 3. The list is not a scientific taxonomy; it does not include all the alleged effects of alternative development patterns. However, this inventory presents a comprehensive set of allegations based on the relevant literature summarized here.

The allegations have been classified into five substantive categories:

1) Public-private capital and operating costs;
2) Transportation and travel costs;
3) Land and natural habitat preservation;
4) Quality of life; and
5) Social issues.

Figure S-1: Markets Where Policies to Change Urban Form are Likely to Have Direct (Internalized) Effects on Prices

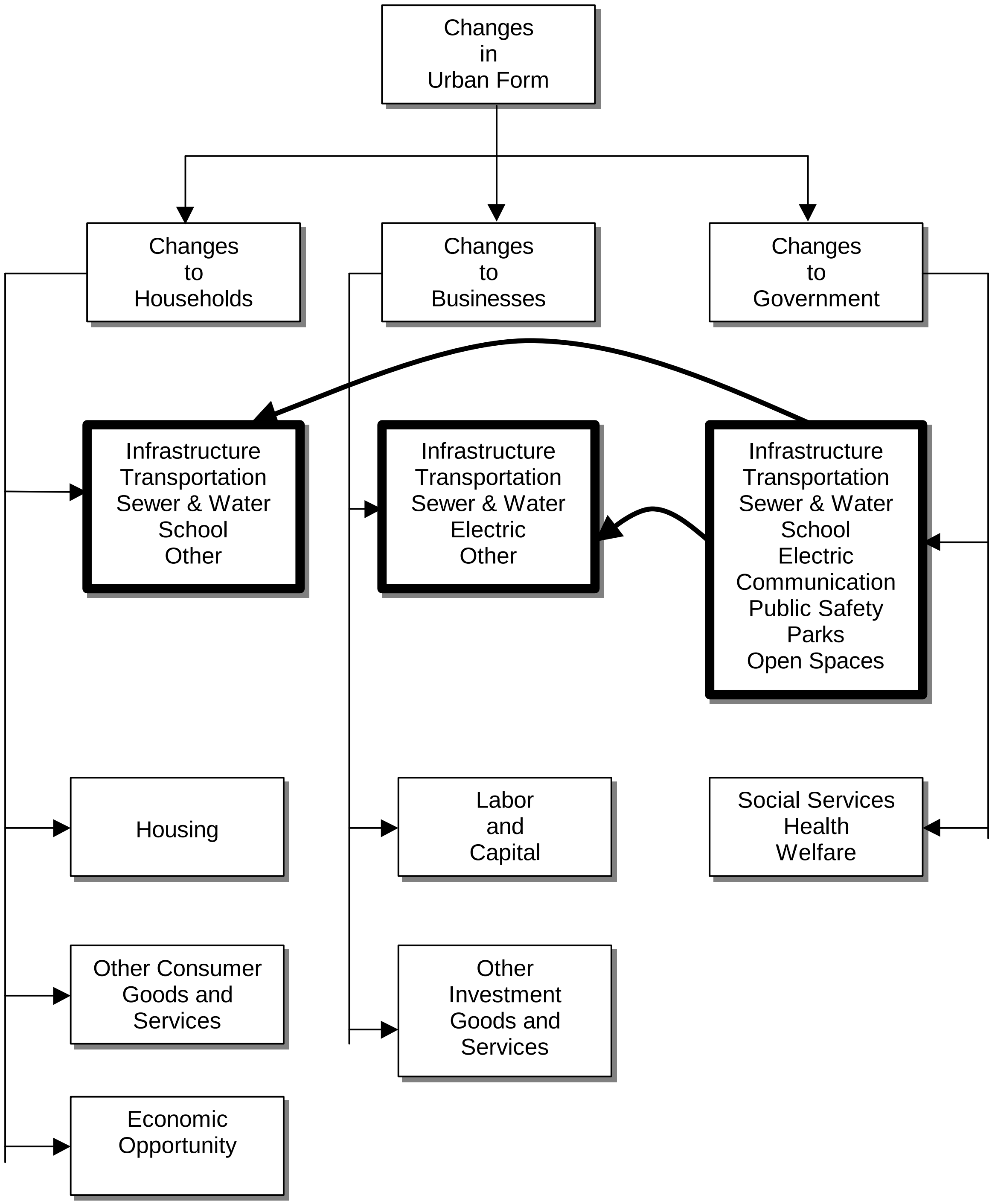


Figure S-2: Alleged Negative and Positive Impacts of Sprawl

Substantive Concern	***A. Alleged Negative Impacts***	***B. Alleged Positive Impacts***
I. Public-Private Capital and Operating Costs	1. Higher infrastructure costs 2. Higher public operating costs 3. More expensive private residential and nonresidential development costs 4. More adverse public fiscal impacts 5. Higher aggregate land costs	1. Lower public operating costs 2. Less expensive private residential and nonresidential development costs 3. Fosters efficient development of “leapfrogged” areas
II. Transportation and Travel Costs	1. More vehicle miles traveled (VMT) 2. Longer travel times 3. More automobile trips 4. Higher household transportation spending 5. Less cost-efficient and effective transit 6. Higher social costs of travel	1. Shorter commuting times 2. Less congestion 3. Lower governmental costs for transportation 4. Automobiles most efficient mode of transportation
III. Land/Natural Habitat Preservation	1. Loss of agricultural land 2. Reduced farmland productivity 3. Reduced farmland viability (water constraints) 4. Loss of fragile environmental lands 5. Reduced regional open space	1. Enhanced personal and public open space
IV. Quality of Life	1. Aesthetically displeasing 2. Weakened sense of community 3. Greater stress 4. Higher energy consumption 5. More air pollution 6. Lessened historic preservation	1. Preference for low-density living 2. Lower crime rates 3. Reduced costs of public and private goods 4. Fosters greater economic well-being
V. Social Issues	1. Fosters suburban exclusion 2. Fosters spatial mismatch 3. Fosters residential segregation 4. Worsens city fiscal stress 5. Worsens inner-city deterioration	1. Fosters home rule 2. Enhances municipal diversity and choice

Each of the alleged negative and positive impacts found in the literature search under these five substantive groupings is examined in depth following a common presentation format as follows:

1) *Topic*.

2) *Allegation/Basis*.

3) *Literature Synthesis*:

   a) Whether or not the alleged factual condition exists under conditions of alternative development patterns.
   b) Whether or not the alleged factual condition—if it exists—has been significantly linked to alternative development patterns.

The literature synthesis is summarized in Figure S-3. Evident from that table is that the field tends to be more prolific on criticisms (costs) than on benefits. It is also obvious that there are more 'physical' than 'social' or 'environmental' impacts of alternative urban forms and development patterns. These physical character istics include travel, especially by automobile; greater consumption of land; and infrastructure costs. By contrast, there is much less literature and even less agreement in the literature on such matters as "stress" or "community" due to sprawl.

With respect to the issue of whether certain costs and benefits are "strongly linked to certain development patterns, such as sprawl" (holding aside the issue of causality), there are a few areas of high consensus, such as sprawl's link to greater automobile travel and consumption of more farm and frail lands. By contrast, there is "no agreement" on many fronts, such as whether housing and land are more expensive under sprawl.

For our purposes, the divergence of opinion which exists on a variety of the impacts of alternative development patterns suggests the need for both caution and flexibility in the application of specific methods to estimate these costs in connection with local and metropolitan development plans. At the same time, agreement on the linkage between alternative development patterns and certain other costs appears sufficient to endorse their use for planning purposes.

A PROTOTYPE ACCOUNTING MODEL

In Chapter 4 of the report we describe the organization and implementation of a prototype model for estimating the Full Social Cost of Alternative Land Development Scenarios (SCALDS) at the regional (MPO) level. The model has been developed using software that is commonly available to most MPO's, the computer spreadsheet (EXCEL). The prototype model consists of 18 interconnected spreadsheets, which produce an aggregate estimate of the full costs of regional land use scenarios.

The SCALDS Model is not intended to be the definitive solution or the cookbook for estimating costs, but a guide to how a metropolitan area might approach this project. Additional tables can be added and local cost factors substituted for the national figures used in several situations.

Figure S-3: Matrix Synthesis of the Literature on Sprawl

	Does Condition Notably Exist?				**Is It Strongly Linked To Sprawl?**			
Substantive Concern	+2 General Agreement	+1 Some Agreement	0 No Clear Outcome	-2 Substantial Disagreement	+2 General Agreement	+1 Some Agreement	0 No Clear Outcome	-2 Substantial Disagreement
I. Public-Private Capital and Operating Costs								
A. Alleged Negative Impacts								
1. Higher infrastructure costs	X					X		
2. Higher public operating costs		X					X	
3. More expensive private residential/ nonresidential development costs		X					X	
4. More adverse public fiscal impacts		X				X		
5. Higher aggregate land costs		X				X		
B. Alleged Positive Impacts								
1. Lower public operating costs		X					X	
2. Less expensive private residential/ nonresidential development costs		X				X		
3. Fosters efficient development of “leapfrogged” areas			X				X	
II. Transportation and Travel Costs								
A. Alleged Negative Impacts								
1. More vehicle miles traveled (VMT)	X				X			
2. Longer travel times			X				X	
3. More automobile trips	X				X			
4. Higher household transportation spending			X				X	
5. Less cost-efficient and effective transit	X					X		
6. Higher Social costs of travel		X				X		
B. Alleged Positive Impacts								
1. Shorter commuting times			X				X	
2. Less congestion			X		X			
3. Lower governmental costs for transportation			X				X	
4. Automobiles most efficient mode of transportation		X			X			

Figure S-3 (Continued)
Matrix Synthesis of the Literature on Sprawl

Substantive Concern	Does Condition Notably Exist?				Is It Strongly Linked To Sprawl?			
	+2 General Agreement	+1 Some Agreement	0 No Clear Outcome	-2 Substantial Disagreement	+2 General Agreement	+1 Some Agreement	0 No Clear Outcome	-2 Substantial Disagreement
III. Land/Natural Habitat Preservation								
A. Alleged Negative Impacts								
1. Loss of agricultural land	X				X			
2. Reduced farmland productivity		X					X	
3. Reduced farmland viability			X				X	
4. Loss of fragile environmental lands	X				X			
5. Reduced regional open space			X				X	
B. Alleged Positive Impacts								
1. Enhanced personal and public open space		X					X	
IV. Quality of Life								
A. Alleged Negative Impacts								
1. Aesthetically displeasing		X					X	
2. Lessened sense of community		X					X	
3. Greater stress		X				X		
4. Higher energy consumption			X				X	
5. More air pollution		X					X	
6. Lessened historic preservation		X					X	
B. Alleged Positive Impacts								
1. Preference for low-density living	X					X		
2. Lower crime rates		X					X	
3. Reduced costs of goods and services		X					X	
4. Fosters greater economic well being		X				X		
V. Social Issues								
A. Alleged Negative Impacts								
1. Fosters suburban exclusion		X					X	
2. Fosters spatial mismatch	X					X		
3. Fosters residential segregation		X					X	
4. Worsens city fiscal stress		X				X		
5. Worsens inner-city deterioration		X				X		
B. Alleged Positive Impacts								
1. Fosters home rule	X					X		
2. Enhances municipal diversity and choice	X					X		

The SCALDS Model has three general calculation paths. The physical development path (Tables 3 through 8) models the consumption of land, the projected mixture of new housing units, the local infrastructure cost and annual operating cost of sewer, water and storm water. It is also possible to project the average amount of non- residential building space needed to support new development. The total travel cost path (Tables 9 through 12) models the annual operating cost of peak and non-peak travel on a passenger miles traveled basis (PMT).

The third path (Tables 10 through 16) models the air pollution produced by transport mode, the energy consumption by transportation and the energy consumed by residential land use in non-dollar units. The residential energy consumption contains a factor that approximates the non-residential energy consumption. This path also estimates the cost of the energy consumed by transport and residential land use. However the transport related energy costs are not carried forward to the summary (Tables 17 and 18) because this cost has already been included in the model elsewhere.

Finally, the third path has an illustrative table, Table 16, that shows a short term projection of the increase in new students from the construction of new housing units. This table estimates the marginal change in the number of school age children and the marginal change in school operating cost. The results from this table are not carried forward to the summary tables because the marginal cost change estimates are only good for the short run. In order to get a good estimate of these projected changes in school age children and school operating cost it will be necessary to undertake a separate modeling process outside of the SCALDS Model framework and then add the results of this process back into the SCALDS Model.

All the elements of the SCALDS Model are shown in Figure S-4. Further, the links between the different elements are diagrammed. Figure S-4 should be a quick guide or “road map” to the discussion that follows.

The starting point for the SCALDS Model is Table 1 – Consumer Price Index (CPI). The Model uses default cost data from a number of different years to estimate the cost of alternative land use patterns.

Table 2 contains much of the basic planning data that a metropolitan area develops during the normal course of creating a transportation planning model for an urban area. These data are developed exogenously or outside of the SCALDS Model and are brought into the model by the MPO. All of the data are aggregated at the MPO level.

Table 3 contains the detailed housing mix for the region that is the basis for residential infrastructure cost and land consumption. The table is an elaboration of the basic housing data added to the model in Table 2.

Table 4 estimates the cost of infrastructure associated with residential construction.
The SCALDS Model uses average costs for infrastructure by housing unit type derived from a study by the Urban Land Institute. The costs estimated by this study have been converted from 1987 dollars to 1995 dollars using the CPI.

Table 5 is a more detailed presentation of the regional employment projections, which are the basis for non-residential land consumption and water and sewer demand estimates. These data are all developed locally by the MPO.

Table 6 converts the employment by sector into building area and land area needed to support development. The process of converting employment to building area demand and land area demand will benefit from the use of local data. The data on floor area ratios, space per employee, and average building size, in the sample model application are taken from a study done by Rutgers University.

Table 7 estimates the demand for water and sewer service and the cost of water, sewer and storm water services for the urban area. The water and sewer demand factors are based on standard engineering assumptions for water and sewer system planning.

Table 8 marks the end of the physical development path in the SCALDS Model. Land consumption forecasts are based on the data in two tables, Table 3 (Housing Mix) and Table 6 (Non-Residential Development Mix). From here the Model is linked to Summary Tables 17 and 18 and then it begins the travel cost path in Table 9.

Table 9 table is the beginning of the travel cost path in the SCALDS Model and is linked back to Table 2 in order to estimate the total number of person trips at an the regional level. The total number of person trips is derived from the total number of households and the average number of trips per household. Total number of trips is allocated to individual modes based on the percentage of trips made by vehicle type. The National Personal Transportation Survey (1990) data is a default value that can be used to make most of these calculations. A MPO with an up-to-date travel forecasting model or local travel data will use these local data instead of nationally estimated values.

Three tables are the heart of the travel cost-estimating path in the SCALDS Model. Tables 10 and 11 contain the estimate of the cost per passenger mile for peak and off-peak travel by all modes except truck. Table 12 is the table in which the number of miles traveled and the cost per mile are combined to produce a total travel cost estimate.

The data used to estimate the cost of transportation is not generally available at the MPO level. MPO’s do not need to maintain these data but to need to know where to look for updates of national cost numbers.

The SCALDS Model tracks the following transportation costs:

Depreciation and Financing Costs
Vehicle Insurance Cost
Registration and Licensing
Gasoline Cost
Maintenance Cost
Transit Fares
Residential Parking Cost
Non-Residential Parking Cost User Paid
Non-Residential Parking Cost – Societal Costs
Accident Costs – Not covered by Insurance
Travel Time
Federal/State Highway Investment
Municipal Services
Government Net Transit Costs (Total Cost – Fare Box Revenue)

Deferred Maintenance Cost
Air Pollution Cost

A full explanation of each is found in Chapter 4 and Appendix A.

Table 13 includes the non-dollar denominated estimates of energy consumed directly by transportation. The total annual energy usage is calculated in a straightforward manner using the estimated total passenger miles by vehicle type as derived in Table 9. Estimated energy consumption can be converted into gallons of fuel consumed by using the factor in the table if a metropolitan area needs this information. While the total energy consumption is calculated here for illustrative purposes, they are not passed on to the cost summary in Table 17 in order to avoid double counting of costs. The data necessary to create this table come from national sources.

Table 14 estimates the cost of energy and the amount of energy consumed by urban land uses. The energy consumption estimates include all the energy consumed by all land uses in an urban area. These estimates do not include any industrial process energy used by large energy consumptive industries such as aluminum smelters.

The energy consumption estimates in this table are derived from a "Place ^{3}s" approach of the US Department of Energy. The Place ^{3}s energy consumption is a first generation effort. It is probable a more complete integration of the Place ^{3}s methodology and the SCALDS Model could be accomplished after some additional study of the operational details of the two models.

Table 15 calculates the cost of air pollution and is not included in the estimates of peak and non-peak travel cost in Tables 10 and 11. The non-dollar cost estimates of air pollution produced directly by transportation is estimated in this table. The pollution estimates are denoted in tons of pollutant per year.

Table 16 is included in the SCALDS Model as a placeholder. At this point in time, the cost estimates and estimates of the number of new students produced in this table is not connected to the cost and non-cost summaries in Table 17 and 18. Table 16 estimates the average number of new pupils and average education costs.

This type of estimate performs well only for short term, local projections of growth because it is based on two assumptions. First, the demographics of an urban area will not change very much in the short term (less than 5 years). Second, the number of students that will be generated from a particular type of housing unit will be the same as recently generated from existing housing units of the same type. Over time it is necessary to use a different model - cohort survival - to estimate the number of school children at a regional level.

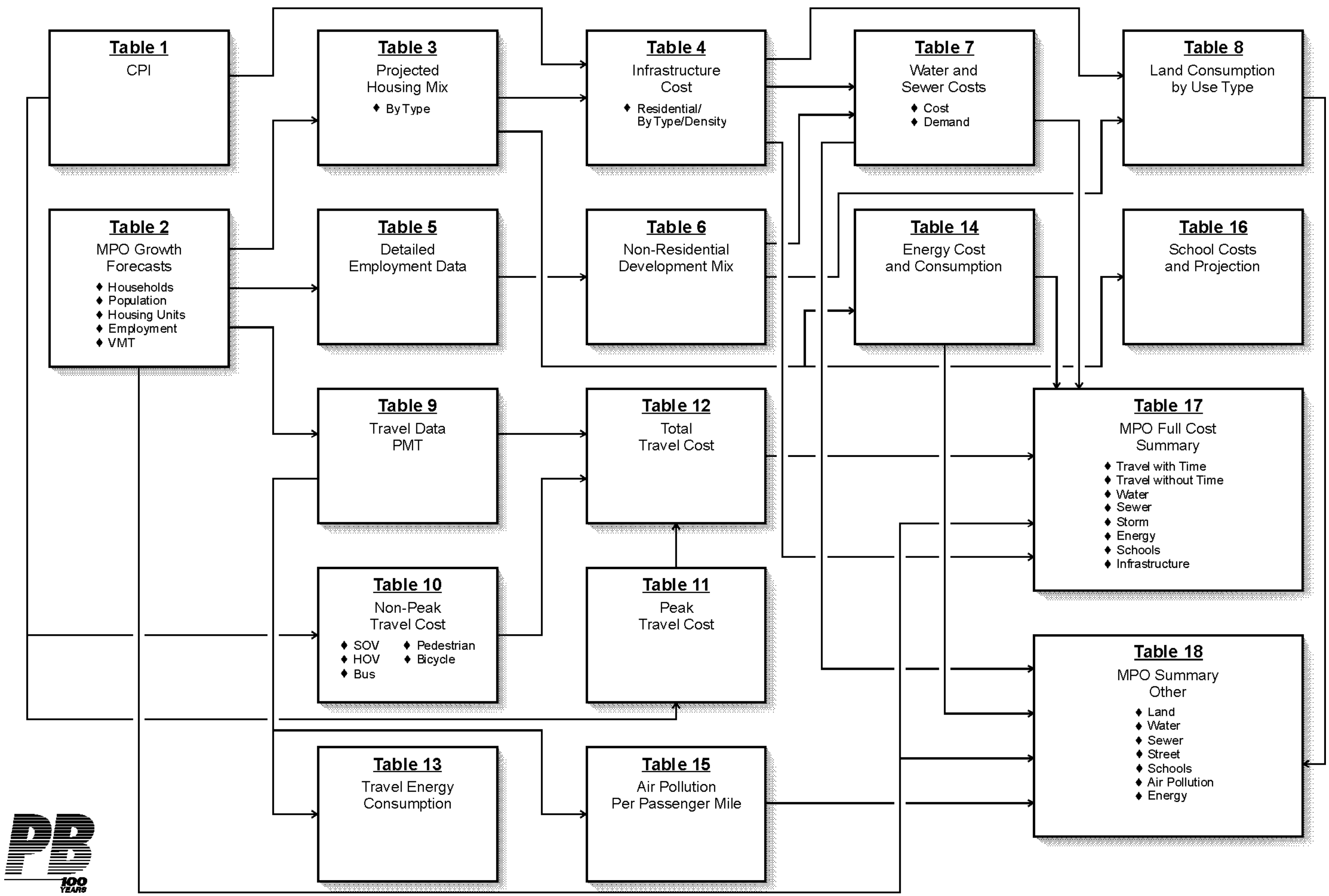
MPO analysts need to take care when using new households to estimate the number of school age children. The demographics of the region are not changed by changing the housing mix.

Tables 17 and 18 contain the summaries of the cost and non-cost estimates developed in the preceding sixteen tables of the SCALDS Model. These two tables can be used to develop scenario comparisons.

NEED FOR FURTHER RESEARCH

The nested set of relationships diagrammed in Figure S-4 framework necessarily encompass a very wide set of behaviors by all sectors of our society and economy, going well beyond the traditional concerns of transportation researchers. From our perspective there are several aspects of transportation research, which need to be addressed in order to fill in gaps in our knowledge of the impacts of alternative development patterns. We identify these in the concluding chapter.

Figure S-4: Full Cost of Alternative Land Use Model Schematic



1.0 INTRODUCTION

This report is part of a series of products, training programs and policy initiatives being undertaken by the Federal Highway Administration (FHWA) and other agencies within the US Department of Transportation to improve the practice of transportation planning, through integrating it with other planning processes (particularly land use planning), and enhancing the process of project evaluation and selection. It extends and applies a report prepared by Parsons Brinckerhoff and ECONorthwest for FHWA, “Least Cost Planning: Principles, Applications and Issues” (September, 1995), in which the authors present a benefit-cost framework for use by transportation decision makers.

The framework has the following principles:

(1) the application of benefit cost techniques,

(2) consideration of policies and investments to reduce demand on an equal footing with those that increase supply,

(3) the acknowledgment of uncertainty in forecasts of future conditions,

(4) the involvement of the public in the development and evaluation of alternatives, and

(5) monitoring of programs and projects to reflect new information about their cost-effectiveness.

This framework is useful for understanding a variety of public policy problems involving transportation related investments. One such application is the evaluation of alternative metropolitan development patterns.

Metropolitan Planning Organizations (MPO’s have been and will continue to be involved in the development and evaluation of alternative Regional Transportation Plans. The preparation of such plans typically include principles (2), (3) and (4), above.

An increasing number of MPO’s are developing and evaluating land use strategies as demand management strategies. The precedents for doing this include work by the Puget Sound Regional Council, culminating in its 2020 plan early in this decade. Ongoing work in Portland, Oregon by the Metropolitan Service District (the designated MPO), and others is advancing the state of the practice in developing and evaluating such plans in the United States.

There is a need to expand further on these and other efforts, in several ways. There needs to be a primer on how to consider the full costs and benefits of alternative land use plans. While transportation impacts are the primary concern of MPO technical evaluations, a more systematic treatment of impacts (costs and benefits) of all kinds is also required. Secondly, there is a need for a summary of current knowledge of these costs and benefits, as defined broadly to include both public sector and private costs, both direct costs and indirect costs, and both internal and external costs. Lastly there is a need to demonstrate the applicability of this approach to decision making, not merely its theoretical or political correctness.

This report is designed to address these three needs -- for a primer on a full cost framework, a summary of current knowledge and a sample method for the application of both. While there is an extensive literature on the costs of alternative development patterns, it focuses principally on direct costs, and on public costs. Only recently has interest in measuring and monetarizing the broader spectrum of costs led to new research on these topics. This topical research is still embryonic. Much work remains to be done.

Much of the debate has focused on the "costs of sprawl." It is filled with assumptions, many of which we explore in the pages which follow. As ISTEA holds promise for reshaping the practice of metropolitan and corridor planning, so the long-standing debate on the types, magnitudes and incidence of development costs, particularly as related to the use of the automobile, weighs down the prospects for reaching consensus on important projects and programs to address urgent public transportation goals and needs. The scope of research of this primer is designed to address these issues.

This report has four major sections. In the first section (Chapter 2.0) we will present an accounting framework for the costs and benefits of alternative development patterns. We define these patterns as being regional in scale-- the scale at which employment centers, neighborhoods and communities sort themselves out spatially.

There are several reasons for focusing at the regional scale. Many of the costs of development are not measured usefully at the scale of a subdivision or a single development project, (unless the project is extremely large), since it is likely that at this scale the marginal costs (both direct and indirect) will vary widely, being largely the product of specific local infrastructure capacity constraints, for example. Further, there is some consensus that the costs of alternative development patterns only begin to be distinguishable when one considers them at the corridor, subregion or regional scale.

The accounting framework we present will include, as we have said, costs which are both direct and indirect, public (governmental) and private, internal (experienced by users) and external (experienced by others). We will attempt to avoid creating a framework which leads to double counting.

In the next section (Chapter 3.0) we will summarize the state of knowledge about the magnitude of these costs and benefits, drawing on current and recent literature. We acknowledge that some cost categories have thus far defied quantification, and that others have not been monetarized, though they have been measured or described.

In Chapter 4.0 we will propose practical ways for MPO's to use the framework and research findings we have developed. We will identify the kinds of data MPO's should try to collect the sources for such data, the issues related to data maintenance and updating, and problems or issues related to the transferability of findings across regions or study areas. We will do this in the context of one particular set of linked spreadsheets, which we use to illustrate how to develop and quantify monetary and other costs of alternative regional development patterns.

In the final section (Chapter 5.0) we identify the research which is needed to fill gaps in the framework, in the state of knowledge and in the tools necessary to evaluate the impacts of alternative development patterns. A lengthy bibliography contains citations for the numerous works mentioned in the report.

2.0 A FRAMEWORK FOR EVALUATING THE IMPACTS OF ALTERNATIVE URBAN FORMS

2.1 OVERVIEW

This chapter discusses a framework for clarifying the impact of alternative urban forms. Such a framework is necessary before anything useful can be done with the many studies and claims about the benefits and costs of different urban forms. It clarifies questions like: What does "urban form" mean and how is it measured? Whose benefits and costs are being measured? How can they be measured in a consistent way that avoids double counting? Such a framework should help MPOs discuss and make decisions about land use and urban form, especially as they relate to transportation.

This chapter contains no new research. It is a synthesis of literature, building on previous work done by the authors for FHWA on a full-cost framework for transportation planning.

The purposes and methods of the report are better understood if one understands the questions that the report does not answer. First, it does not address the question, Does urban form affect travel behavior? (Parsons Brinckerhoff, 1996b, c, d). We assume that it has and does.

Second, it does not address the question, can public policy affect urban form? We assume that it can. It certainly can and has in theory: federal investment in highways and the home-interest tax deduction are two examples.

More to the point, can a multi-jurisdictional region adopt and implement policies that would change the form of development that current market conditions yield, given market forces, local and regional politics and public involvement (including neighborhood opposition)? We assume that it can. How much would urban form have to change to make a measurable difference in net benefits? What are the costs (including the political ones) of that magnitude of change? Can the average (or any) metropolitan area be expected to make that magnitude of change given these costs? Answers to these questions must come from individual metropolitan area local governments and citizens. This report contains information to help staff and citizens answer these questions.

In this study we define urban form to be the regional pattern of urban development, in contrast to a site-specific pattern. We are not evaluating the form or design of any particular subdivision, but the pattern of all subdivisions. The analysis occurs from an altitude of about 30,000 feet.

Discussions in MPOs about urban form are almost certainly also discussions about density at both the aggregate and site level. In other words, most planners advocating the kind of changes in form we discuss in this report would consider such changes a failure if they did not cause corresponding localized and regional increases in density. Density can be measured in many ways: by housing type (e.g., single-family vs. multi-family), by other correlates of density (e.g., amount of park and open space); as persons per residential acre, as persons per gross acre (Downs, 1992), or in the aggregate as total population divided by total metropolitan (county) area (Ladd, 1992).

There is no right definition of density; it depends on the question being addressed. In this report we sometimes refer to density at the small level (e.g., an urban form that creates new single-family detached units at the relatively high densities of 15 units per net acre), and sometimes at the large level (e.g., overall changes in the average density of dwelling units or population) and try to be clear each time about which measure we are using and why.

Related to both form and density is sprawl. Audirac (1990, 471) contends that “there is no consensus on definitions of urban sprawl - its physical characteristics, causes and effects.” She believes, as we do, that sprawl connotes negative impacts like costliness, ugliness, and environmental damage. Ewing (Ewing, 1994) adds that sprawl is a matter of degree, but that it has the pejorative connotations of development that is unplanned, low density, distant, leapfrog, centerless, and homogeneous. [1]

A concurrent project for the Transportation Cooperative Research Program (TCRP Project H-10, “The Costs of Sprawl Revisited), expands the definition of sprawl to include what we refer to as governmental and legal characteristics, arguing that sprawl is characterized by small-scale ownership, fragmented governance and local variations in fiscal capacity and local tax base. These characteristics, while almost certainly correlated with the physical features of sprawl, are not its inevitable consequences. For example, it is easy to hypothesize (and not difficult to find) urban areas where sprawl has occurred within a single-city urban area. Similarly, in central city single family detached housing and condominiums would show a smaller scale of ownership than what most people would agree to be suburban sprawl.

For the purposes of this report, we prefer to stick with definitions of urban form that limit themselves to the form itself (rather than including its correlates and effects) and not to use “sprawl.” Sprawl implies a value judgment (a negative one) about the location, mix and design of development, several of the characteristics of urban form that occur in metropolitan areas.

Most of the discussion about controlling urban form is aimed at the desirability of reducing sprawl; increasing the amount and mix of development in centers; increasing the amount of residential development that is multi-family; increasing the average density in units per net acre for all types of housing; and (as a result of all the above) decreasing the land consumed by a given population (which means increasing average regional density in the aggregate). In this study we focus more on the question of the impacts (benefits and costs) of public policies that would change urban form in the direction of more subcenters, greater local and regional density and greater mix of uses.

Attempting that focus is not the same as achieving it. The purpose of this report is to make the types and amounts of effects of alternative urban forms more clear. The reader is warned, however, that whatever clarity may filter out at the end of this report comes only after a heavy dose of clarifiers that will initially make the mix muddier. A conclusion we will repeat is that metropolitan areas are complex places, where billions of transactions and activities occur daily.

---

[1] Ewing (Ewing, 1994, 2) concludes that “Ultimately, what distinguishes sprawl from alternative development patterns is poor accessibility of related land uses to one another.” In other words, he shifts from a definition of sprawl based on land use and design to one based on transportation.

No models of urban areas come close to summing all the impacts that each citizen endures or enjoys. Models of urban areas that attempt to even partially address major interactions and impacts are immediately too complex to explain to even an informed lay audience. Without such models, or the framework we attempt to describe in this report on which those models would be built, the analytical debate is reduced to headlines, bumper stickers and sound bites: growth is good, we need family wage jobs, all ships float on a rising tide, don't Californicate [your state here], sprawl decreases quality of life, compact growth is more efficient, and so on.

Ultimately, the choice of public policies to affect growth and urban form is a local one. It is our intent in this report to inform the debate.

2.2 REGIONAL EFFORTS TO CONTROL URBAN FORM

There is a long history of regional planning in the United States. All of those regional plans have a physical component. In that sense, any master plan for a region or metropolitan area is about trying to control urban form with persuasion, regulation or incentives.

One can find similar efforts when the view is focused from the regional to the local level. Efforts to build new towns like Radburn, Reston, Columbia and Laguna West are about changing urban form at the level of a city. The typical land use policies of zoning and subdivision ordinances, common to almost all cities, are also efforts to use policy to influence urban form. More recently, these traditional tools have been augmented by regulations and incentives that fall under the heading of growth management.

Our purpose in this report is to provide research results that (1) are useful to MPOs, (2) emphasize transportation relationships, and (3) focus on recent (post-ISTEA) examples rather than old ones. Thus, we should begin our search for a framework for evaluating the benefits and costs of changes in urban form by reflecting on recent efforts by MPOs and other regional authorities to integrate transportation planning with land use planning, and to influence urban form.[2]

Moore and Thorsnes (Moore and Thorsnes, 1994) summarize some of the features common to these regional planning efforts. Key points germane to this research are:

- Land use planning is usually at the center of regional planning. Thus, regional planning efforts usually focus on how the urban area could look different than it would have otherwise. The desired difference is usually in the direction of more centers and density. [3]

- At the regional level, the options for urban form are few in theory and in practice. For any predicted amount of growth, a region can (1) continue what has in U.S. cities been a universal pattern of suburbanization (residential growth accommodated in relatively low density development, primarily at the urban fringe); (2) try to get that growth to concentrate more in the central city and major subcenters within the existing metropolitan area; or (3) deflect the growth to satellite cities not contiguous to the metropolitan area. For most

[2] This section draws on planning efforts the authors have participated in or studied.

[3] That conclusion is generally true historically and probably true without exception for recent metropolitan planning efforts in North America in the last five years.

metropolitan areas the best prediction about urban form is “what you see is what you’ll get” - the transportation network, infrastructure and significant concentrations of buildings already dictate most of the future pattern at the regional level.

- The goals that emerge from regional planning processes are remarkably similar. Regions want to increase economic opportunity and urban amenity without decreasing environmental quality. They hope to do that by locating land uses where they can be served efficiently, and by then supplying those services efficiently. They hope that all groups can share in the benefits of regional growth without disproportionately bearing the burden of its costs. Broadly defined, “urban amenity” includes not only good design, cultural diversity and parks, but also public safety and sense of community; “environmental quality” includes not only water and air quality, but also preservation of agricultural land; “services” include not only infrastructure, but also social services.

- What starts as a discussion about land use, urban form, or transportation inevitably arrives at a need to consider a wider range of impacts and policies. Goals overlap and goals and criteria based on them don’t add up. In other words, the discussion inevitably leads planners and policymakers to want some framework for keeping track of the multiple effects of changes in policy.

- As a result, the link between general goals and specific criteria for comparing alternatives is weak. Moreover, “there is almost always a logical gap between criteria and prescription that is usually bridged by rhetoric.” (Moore and Thorsnes, 1994, 95).

- Even with a proper framework, measurement may not be possible. Even if the measurement were possible, the rating and ranking of different measurements has no unambiguous technical solution: it is political.

- Public involvement remains extremely important.

These conclusions about regional planning lead us to conclusions about what our research should focus on.

Regional planning efforts get to general goals without much difficulty. Where they have problems is in evaluation. They lack both a framework for thinking about the impacts of policies, as well as ability to evaluate strategies influencing urban form and measurements consistent with that framework.

The rest of this chapter focuses on developing such a framework, one that is comprehensive (all significant benefits and costs are counted) and mutually exclusive (they are counted only once). It addresses such questions as: What are the impacts (benefits and costs) of alternative urban forms? What are the causal relationships among those impacts, including how public goals and policies about urban form interact with market forces?

Chapter 3 summarizes the state of knowledge about measurement. Subsequent chapters suggest how MPOs could use the framework and measurements to evaluate alternative urban forms.

2.3 PRINCIPLES FOR A FULL-COST EVALUATION FRAMEWORK[4]

The principles for a full-cost evaluation framework [5] have been well developed in several different literatures. Generally, the literature of policy analysis, benefit-cost analysis and program evaluation describes in detail all of the principles we will briefly summarize below. More specifically, many utilities (especially electric and water utilities) have tried to incorporate these principles into their project evaluation and long-run planning. [6] The idea of disaggregating transportation projects into component benefits and costs has been discussed and occasionally applied for over 50 years. [7]

Every investment decision, whether in the public sector or the private sector, should attempt to maximize the excess of benefits over costs (net benefits). In the private sector, net benefits to firms are measured through profits (net revenues): firms make decisions about what type and quantity of goods or services to produce based on their predictions of how much of those products consumers will buy at a given price and how much it will cost to produce those goods.

The optimization of private investment decisions can be measured approximately by profits. The public sector, however, has other objectives beyond what can be stated in terms of net revenues. Benefits might be the decreased travel costs to commuters; decreased air pollution; or a feeling of stewardship enjoyed by some people when the government enacts policies to discourage sprawl and increase transit ridership.

Benefit-cost analysis is the general term used by policy analysts to refer to both a logical framework and specific techniques for measuring and comparing all the significant benefits and costs of a public policy. [8] In a narrow sense, some texts and critiques of BCA refer to it primarily as a technique for calculating the net present value of a future stream of direct, quantifiable, monetary benefits and costs. In the fuller sense that we use here, it is a framework that helps analysts and decision-makers (1) identify and quantify all benefits and costs of a proposed action, (2) avoid omitting or double-counting benefits or costs, (3)

---

[4] Much of this section is from our report to FHWA (ECONorthwest and Parsons Brinckerhoff, 1995). The general principles of a full-cost evaluation are the same whether they apply to transportation, land use or any other field or activity.

[5] In this report we use the term *full-cost evaluation* as it is used colloquially: full-cost means making sure all costs (and, by implication, benefits, which are negative costs) get counted. By that definition, a full-cost evaluation is no different from a benefit-cost analysis. The professional literature occasionally uses the term *full-cost pricing*, which refers to "a policy strategy based on the idea that the economy would benefit from imposing the discipline on each enterprise that all its costs should be recovered from consumers, i.e., total user revenues should equal total costs for each activity." (Lee, 1994).

[6] The literature in the electric industry on benefit-cost analysis, least-cost planning, integrated resource planning and the valuation of environmental impacts is huge. For a recent review of the application of benefit-cost principles to the valuation of environmental impacts, see ECONorthwest, 1993.

[7] For the general application of benefit-cost analysis to transportation, see AASHTO (1977), Lee (1994), and Greene & Jones (1995). For specific applications of benefit-cost analysis to transportation, see Lee (1995a), and Wilbur Smith Associates & Howard Needles Tammen Bergendorff (1994).

[8] Many texts and documents explain the principles of benefit-cost analysis. For a good general introduction see Gramlich (1981), Thompson (1980), Mishan (1982) and Stokey & Zeckhauser (1978).

determine how future benefits and costs should be valued today and (4) estimate how benefits and costs are distributed among different groups.

The rationale of benefit-cost analysis is economic efficiency; it aims to ensure that resources are put to their most valuable use. Its fundamental rule is:

> "In any choice situation, select the alternative with the greatest net social benefit." (Stokey & Zeckhauser, 1978)

Any choice is evaluated in relation to no-action (or, rather, a business-as-usual) alternative - if the no-action policy yields greater net benefits, then the best policy is to do nothing. Benefit-cost analysis recognizes that policy alternatives may make some people better off and others worse off. Such distributional changes are inevitable. But the fundamental rule at least requires that in the aggregate there is more value after the action than before. In theory, those who benefit from the change could compensate the losers leaving everyone better off. Whether the losers do, in fact, get compensated is part of the evaluation of the equity impacts of a policy that policy-makers must consider along with the evaluation of net social benefits.

The overarching strength of the full-cost approach to evaluation is the framework it provides for identifying and discussing benefits and costs. It facilitates a comparison of different types of benefits and costs occurring at different times and affecting different people. It focuses on comparing the real resources available before the project with the real resources available after the project. If done correctly, it considers not only direct dollar costs (like labor and materials) but also costs and benefits not usually measured in dollars (like environmental damage and decreased congestion) and the distribution of all benefits and costs. Thus, in contrast to critiques of a benefit-cost framework that assert that it only looks at dollar costs, it provides a useful framework for a comprehensive analysis of all the benefits and costs attributable to a project, whether they are measurable in dollars or not, and to some degree, even if they are not quantifiable. [9]

Evaluating All Significant Benefits and Costs

Many of the costs of different urban forms can be measured by adding up the market costs of the resources the different forms of development use up. Supplying sewer and water to new residential development takes labor (planning, design, construction), concrete, steel, machinery and so on. The costs can be added and expressed in dollars. Many of the benefits and costs of public projects, however, are ones not typically registered through market transactions. Some of these benefits and costs are not internalized in the prices paid for the goods and services needed to build and operate the project - for example, the costs of air pollution on people and property near highways where automobiles generate that pollution. Economists call such costs spill-overs or externalities, and argue that society should consider them in its evaluation of a project since they result in real gains or losses.

Without an acquaintance with the fundamental concepts and methodological issues associated with a full-cost framework, planners and policymakers will be unable to take the first steps towards a more comprehensive evaluation of alternative urban forms, and the policies and investments that cause them to occur. Some of the main concepts and issues are:

---

[9] For a thorough discussion of the strengths and weaknesses of BCA, see Campen (1986).

- *Costs are real economic resources used by a policy or project.* Money facilitates the exchange of useful resources, but is not a resource itself. Steel, concrete, labor and land *are* real resources that get used up in the process of building cities. Concrete laid in a freeway is concrete not available for a sidewalk, and vice versa. Economists express this point by referring to *opportunity cost*: the value of a resource in its next best use (if it hadn't been used for what it was, in fact, used for). Most goods in a market economy sell at their opportunity cost - thus market costs can be used to measure the value of many benefits and costs.[10] The cost of goods purchased from subsidized markets (e.g., goods purchased from the public sector) may need to be corrected to account for the true economic cost. Costs should be counted whenever, and only when, resources are used up.

  This point has some important implications. It is not uncommon, for example, for evaluations of development projects to count costs as benefits, and sometimes more than once. To build a convention center or a sewage treatment plant, one must use up labor. It is a cost. But evaluations often count it as a benefit (income to the economy), then double or triple it (the multiplier effect), and then count it as a benefit yet again under the heading of *jobs*. While this may be good politics, it is not good policy analysis. A related point is that what are often listed and added as either benefits and costs are really *transfers*. Taxes and grants are usually transfers (see the note following on *perspective*): money may move from one place to another, but no resources are used up.

- *Benefits are negative costs; costs are negative benefits*. Many of the benefits of different development patterns may be best expressed as reductions in the costs that would have been incurred if other development patterns had occurred. For example, a benefit of a denser urban form may be a reduction of the infrastructure costs that would occur if development were to occur less densely.[11]

- *Benefits and costs must be defined in a way that is both comprehensive and mutually exclusive*. Clearly, accounting for all benefits and costs requires identifying a comprehensive list of all (or at least the significant) benefits and costs. Otherwise some will not be counted. It also requires, however, that the categories not overlap, or else some will be counted twice. For example, transportation evaluation typically counts (as it should) reductions in travel time as a benefit. Many evaluations, however, go on to count as benefits increases in property values and tax revenues that such reductions in travel time stimulate, double- and triple-counting the benefit (Mishan, 1978, 67).

- *Consumer benefits are measured using information on consumer demand*. The difference between what consumers are willing to pay to make a trip and what they actually do pay is known as *consumer surplus*. The concept of consumer surplus is central to evaluating transportation investments. It is, in concept, a measure of net benefits (the benefit being what a consumer would pay, the cost being what a consumer did pay.

- *Measuring all benefits and costs means considering some that do not have obvious market prices*. The most obvious example is loss of environmental quality from pollution (e.g.,

[10] Assuming there are no significant external costs, a rebuttable assumption.

[11] Whether something is categorized as a benefit or a negative cost *can* be important, however, if one is making decisions based on the ratio equivalent subtraction (negative costs) from the denominator.

from tailpipe emissions). Less obvious is the loss of time because of congestion. Though air quality and travel time are not traded in any established market, they still are real impacts that must be considered in any full evaluation of the impacts of transportation investments.

Figure 1 shows, in concept, what a full-cost accounting framework must consider. It is quite general - we will investigate the details of its application to issues of urban form shortly. For now, however, we use the figures to make some points critical in developing a full-cost framework for evaluating changes in urban form:

- A full-cost accounting framework, despite its name, must look at *all* impacts, both benefits and costs, that result from a defined change in the state of the world (in the case of this study, either a change in urban form or, more correctly, from a change in policy that attempts to change urban form).
- A full-cost accounting framework must consider all the people affected by the change. Many people may feel the change not just as residential consumers, but also in their capacities as employees of businesses and government. The aggregate net change in efficiency/welfare is important; so is the distribution of that change.
- A full-cost accounting framework must consider impacts at various points during the expected life of the change. It is not enough, as often occurs in regional planning exercises, to describe a desirable end-state 20 to 50 years hence and then describe how well it works and benefits people. One must consider the period of time during which those benefits accrue.

Figure 2 organizes impacts based on their size and how they are likely to be measured. At this general level, the boxes in the right-hand column are comprehensive (all impacts are identified) and mutually exclusive (provided each specific impact is measured by only one of the techniques).

As long as the discussion stays general, the idea of *full cost* is not difficult to explain. People and firms make location and design choices predominantly based on the market prices they face. If one takes the top off the boxes in the right column, however, out pop Pandora's plagues for policy analysis. Some of the benefits or costs of those choices are not internal to the market prices and market transactions: they are *externalities*. In Figure 2 all the highlighted boxes except the one labeled "market prices" are primarily containers for external costs and benefits.[12]

[12] There is an extensive literature in environmental economics on the valuation of external costs and benefits. Economists are concerned with how people derive value from an environmental resource. The emphasis until recently has been on value in *use*. That emphasis had been on resources as inputs to typical production processes (trees provide lumber; water provides cooling; mountains provide metals, and so on), but increasingly has to consider the in situ value of the environment (for uses like recreation and natural cleansing of air and water). Now, economists also recognize the potential of *non-use* values such as option value (I don't use it, but it's worth something to me to have the option to use it in the future), existence value (I don't use it but my life is better because I know its there) and bequest value (I don't use it, but the ability to pass it on to my children has value to me). We do not get into the details of these components of value in this report.

Figure 1: Overview of a Framework for Classifying Benefits and Costs

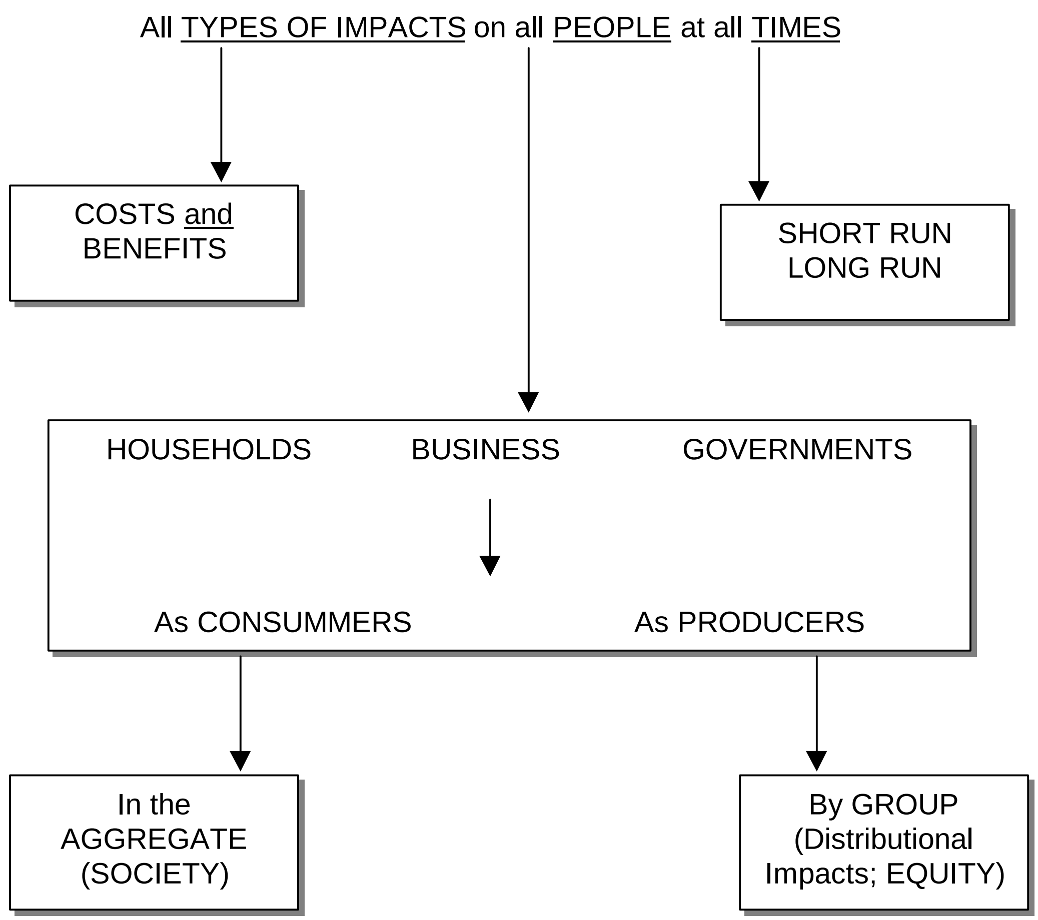
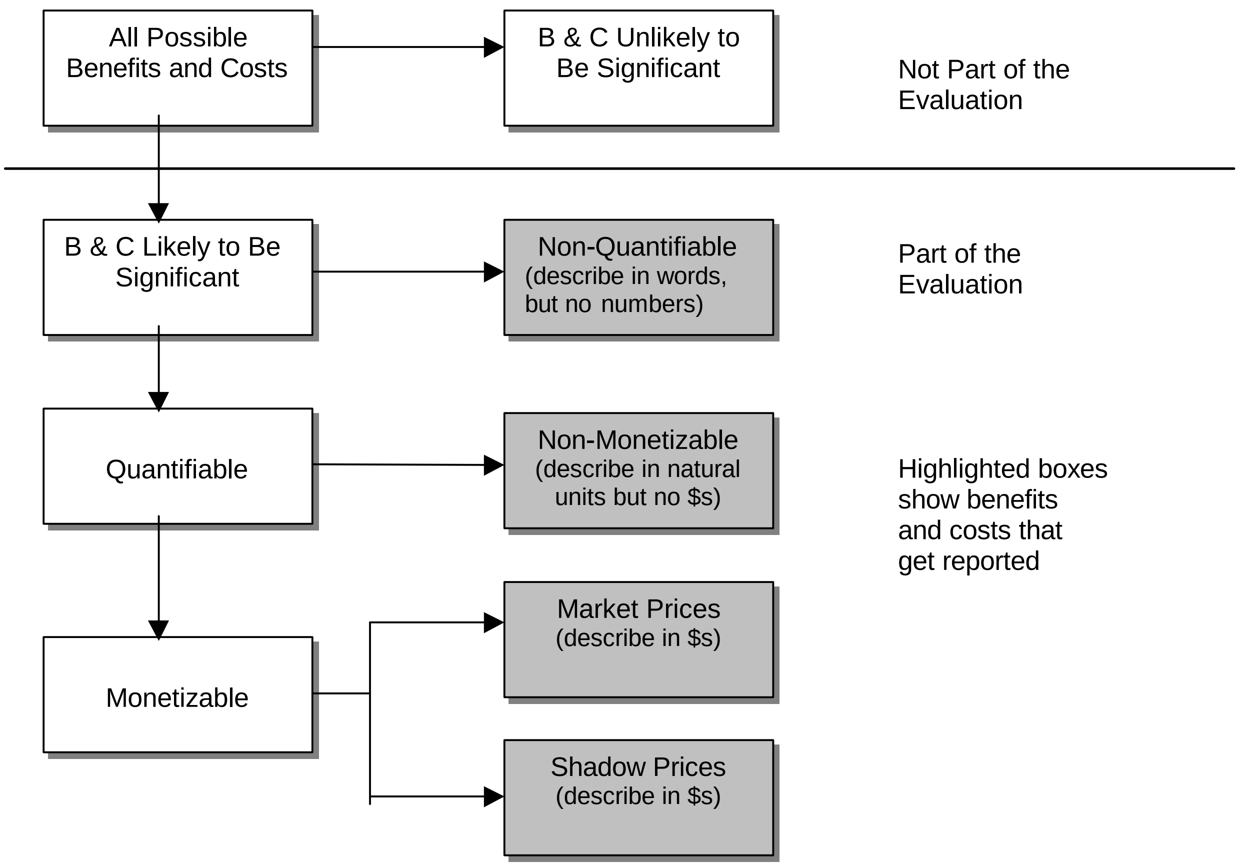


Figure 2: General Framework for Classifying Benefits and Costs, Based on Units of Measure



Other important dimension of a full-cost framework not illustrated in this diagram.

OTHER CLASSIFICATIONS OF IMPACTS	The framework above categorizes impacts based on how they can be measured. There are other ways that they can be grouped – we explore them later in this chapter.
TIME	The framework above is static. Impacts occur over time. Some occur immediately, others in the more distant future. Distant impacts are more uncertain and less valuable; they must be discounted to their present value.
INTERACTIONS AMONG IMPACTS	The framework does not show how the categories of impacts or their causes interact. Policies to change urban form send signals to various urban markets that result in changes in price, consumption, and production.
DISTRIBUTION OF IMPACTS	The framework above is aggregated for an entire region. It does not show that people are impacted differently by changes in urban form. An analysis of the distribution of impacts might show differences by geographic sub-area, by income, or by ethnicity.

If the value of the externalities to society is not great (though the number is not agreed upon) then they can probably be ignored - even if they were included in prices, the location choices probably would not change. The greater the magnitude of the external effects, however, the greater the likelihood that location decisions made on the basis of current market prices are inefficient for society as a whole. That is the argument, sometimes implicit, of those who oppose sprawl; it imposes so many external costs on households, firms, and governments, now and in the future, that society would be better off to change the pattern of development through regulation.

A key question for this study, in the context of Figure 2, is, “How big are the boxes in the right hand column (and what units are being used to measure bigness)?” Thus, a restatement of the purposes of this study is: figure out all benefits and costs so that external ones can be identified and then review the literature to determine whether they are likely to be large or not.

As soon as the discussion gets more specific about impacts, however, it also gets more confusing. First, there are all the obvious problems of just describing a list of benefits and costs that derive uniquely from changes in urban form and are comprehensive and mutually exclusive. Included under that heading is the problem of dealing with direct and indirect (or primary and secondary) effects. We address that problem in more detail shortly. Second, one must sort out the external costs from the internal ones. A large share of costs and payments for goods and services are between private consumers and suppliers. Third, there is still a debate about whether externalities as a concept is well enough defined (Greene and Jones, 1995).

The bottom of Figure 2 makes the point about complexity in a different way. It identifies many things that the organization does not cover. In doing so, it begins a discussion of the complexity of a full-cost framework.

The main points are easily summarized: (1) all significant effects of a project - whether pricable or not, whether quantifiable or not - must be considered in the decision-making process and (2) the effort is worth it, to facilitate efficient decision-making.

Dealing with the Long Run

Assume that all costs and benefits have been identified, categorized properly to avoid double-counts and transfers, quantified and monetized. It is not enough to simply add them up. Benefits and costs that occur at some time in the future are worth less to most people than are the same benefits and costs occurring today.

Being clear about the short run, the long run and everything in between is particularly important in a discussion of the benefits of changes in urban form. Most analysts acknowledge that many of the purported benefits of the policies to reduce sprawl are long run: it takes a while to make any significant changes in the pattern of development of a metropolitan region. But many of the costs of changing that pattern - especially the costs to land owners and developers of changes in policy - begin to occur immediately. A full-cost framework must evaluate and discount impacts that are uncertain and in the future.

Perspective: Benefits and Costs from Whose Point of View?

Not only must all effects be considered, but they should also be considered from all important perspectives. For example, a grant from the federal government to a metropolitan area is an expenditure for the U.S., a revenue for the region the MPO serves, and a transfer from the perspective of net social (national) cost. The distinction between a regional perspective and a local perspective is essential for two reasons.

First, net benefits to a region as a whole do not ensure net benefits to every subset of the region. For example, though policies that mandate greater density may provide net benefits to the region considered as a whole (i.e., the costs, including costs to local neighborhoods that are not easily quantified, are more than offset by the benefits of, say, reducing public facility cost and travel time), local residents near areas targeted for upzoning may oppose it because they genuinely believe that they will be worse off (for example, because they lose their land, privacy or quality of life).

Second, the recommendation that benefit-cost analysis consider not just gains in economic efficiency but also how those gains are distributed is another way of saying that it must consider different perspectives. In the previous example, an analysis done from the perspective of the residential neighborhood would have shown net losses if all external costs had been counted.

Different perspectives (local and national, regional and neighborhood, renter and owner, low income and high income) are all legitimate and inherently in conflict. In practice, few benefit-cost analyses provide rigorous evaluations of how benefits and costs fall on different groups. [13] Part of the reason for the absence of equity analysis is that it can often be difficult to determine to whom the benefits of a policy decision ultimately accrue. Market forces tend to shift benefits and costs from the nominal recipients or payees to others. For example, the time savings benefit from a transportation project initially goes to users (who presumably are local) but may eventually be captured or shifted to landowners (who could be non-local) in the form of higher rents.

There is no economic or mathematical solution to the problem posed by distributional issues except in the instance when all groups are clearly better off under one alternative than another. All a careful analyst can do is describe the likely impacts on different groups or try to help the decision-maker select among alternatives. In our opinion, however, any evaluation of the *efficiency* of policies to change urban form should be done from at least a regional perspective, with inter-governmental transfers identified as just that: transfers, not wealth generation.

Marginal Analysis: Focusing on Differences Among Alternatives

Project evaluation can be simplified by looking at *differences* between what the world is forecast to be like without the project and what it is forecast to be like with the project. If, for

[13] A good example of an exception is *Efficiency and Fairness on the Road* by Cameron (1994). It provides a clear illustration of how an analysis of transportation projects and policy can consider differences in effects on different income groups. That report on the fairness and efficiency of highway policy in the Los Angeles area also illustrates many other concepts and analytical techniques we describe in this report.

example, all the relevant policies for urban form being considered are estimated to have roughly the same impacts on the regional economy, then one can skip spending time trying to estimate those effects: they net out and make no difference to decision-making. For choosing among alternative actions, it is sufficient to know how their effects (impacts) are different.

It is easy for evaluations of policies to manage urban growth and change urban form to miss this critical point. For example, sometimes the base case (the "without new policy" world) is simulated as a simple extrapolation of recent trends, with the result that growth continues at relatively low densities and congestion goes to level of service F on many major corridors. Any policies or projects (the "with new policy" worlds) look good by comparison. The problem is that the base case is a fiction that would never occur. The models that would predict how travelers would respond to that level of congestion (in the short run, with changes in route, travel time or mode; in the long run, with changes in vehicle type and residential and employment locations) and how land uses would change as a result of that congestion are either not available, not acceptable or not used. The need to estimate net impacts means better predictive models must be developed and used.

In all cases the concern should be with the responsible estimates of *the additional (marginal) costs and benefits* resulting from a proposed action.

Is A Full-Cost Evaluation Worth Pursuing?

The typical criticism of the kind of full-cost framework implied by the principles above is that, while impeccable in theory, it is impractical in application. One must, however, consider the alternatives. At the extreme, one could argue that the complexity of metropolitan areas, coupled with the unwillingness of the public and policymakers to give much consideration to the long run, means that a full-cost framework is both impossible and irrelevant. That conclusion relegates policy evaluation to policy packaging - data are collected piecemeal in the service of politics.

That may be the right view. We are less pessimistic. Though short-run political decisions about policy hold sway, we believe they can be influenced by analysis and that a case can be made that the analysis that typically influences them now is flawed for lack of a framework. People understand intuitively that the interactions of markets and policy in metropolitan areas are complex. But because technicians have not been able to disentangle that complexity in any way that the public can understand and use, discussion is informed only by piecemeal, partial analysis.

For most policy analysts, a full-cost framework is analytically compelling, though practically daunting. There is no better way to evaluate policies than by trying to account for all benefits and costs using the principles described above. There is no categorization of benefits and costs that is clearly superior in all respects to some variation on the one in Figure 2. Any other framework for evaluating policy alternatives is likely to be analytically inferior, though it may be chosen by those who believe that the complexity and uncertainty of metropolitan systems are so great as to defy any rigorous accounting of benefits and costs.

2.4 RECOMMENDATIONS FOR A FULL-COST FRAMEWORK

We cannot develop in this report a framework that comprehensively shows all the interrelationships among the factors that affect and are affected by urban form. The figure would fill a wall and would have connections showing primary or secondary affects among most factors. Though such a diagram may be worth developing, it cannot be done here. [14] Second, the opportunities for double-counting impacts are innumerable. Disaggregated approaches to identifying and measuring impacts can easily lead to dozens of categories of potentially significant impacts. The more categories of impacts that one tries to measure, the more likely the double counting.

Third, we believe that one cannot evaluate a change in urban form independent of the way in which urban form will be altered (e.g., increasing the density of growth along radial transportation corridors would potentially have different effects than changing the mix of uses in existing subcenters) and the policies by which those changes will be achieved (e.g., achieving a given urban form by increasing the price of service extensions will have different benefits and costs than achieving it with an urban growth boundary). [15] It is impossible to be comprehensive about evaluating the benefits and costs of changes in urban form without discussing the costs of implementing the policies by which one hopes to effect those changes.

That said, we can summarize our conclusions about the components such a framework *should* contain:

A framework that begins with an accounting of infrastructure costs, to both the public and private sectors, is a good choice for this assignment, since, it is the point at which public discussion about costs and impacts of alternative development patterns almost always begins. Elected officials are most familiar with this subject. MPOs, other agencies of government and researchers have studied this, and the literature on the structure costs of alternative development patterns is deeper than any other topic on the preceding figures.

The framework needs to recognize the three traditional macroeconomic sectors: consumers, businesses and government. Discussions about the trade offs between payment by consumers and business and payment by government is particularly lively regarding

[14] The most rigorous recent work with which we are familiar that has tried to address issues of the benefits and costs of different urban forms has done so without the formal development of such a model. Lee (Lee, 1992, 24) concludes that the proper pricing of transportation would lead to city forms that look "considerably different from current ones, and surprisingly like the ideal cities described by physical planners from another era… Urban areas would provide higher environmental quality, and would be more clustered into nodes." Lee starts with policies that do not aim directly at urban form (changes in the pricing of urban transportation) and then reasons to the effects on urban form. The initial charge for this report worked in the opposite direction : start with policies that change urban form, and work to the impacts on everything else.

Downs (Downs, 1994) argues for a new vision of metropolitan growth that includes higher densities in growth areas; he then provides a descriptive analysis of the likely impacts of those increased densities. In that sense, he is proceeding along the same lines as the analysis in this report, but without formally identifying all the benefits and costs likely to be significant.

[15] That conclusion is implied in the work of Downs (Downs, 1994) also. His analysis of the impacts of higher density is coupled with a discussion of the kinds of policies available to achieve those densities. Moreover, in the dynamic markets of metropolitan areas, the most likely way that a major change in urban form will occur (absent substantial changes in market prices) is through changes in public policy, which send signals to markets that then accelerate change.

infrastructure costs, but it is equally important for other types of impacts included in our framework.

As we have already stated, the framework must deal with both direct, internalized and indirect, external impacts. Infrastructure is a major direct impact, and the impacts on households are the subject of extensive interest. As we shall see in the next chapter, the literature on indirect impacts is spotty, because some topics have not been researched frequently and other topics, while researched, are far from settled in terms of a consensus on the magnitude of their impacts.

These three points lead us back to Figure 3 as being most useful pictorially as a descriptor of the framework required for analyzing the impacts of alternative development patterns.

Figure 3 shows our hypothesis that the main effects of a change in form should be captured through changes in the costs of providing infrastructure services. As the title of Figure 3 implies, an important and defensible assumption is that the effect of urban form on households, businesses, and governments occurs mainly through a derived demand for infrastructure, an intermediate good.

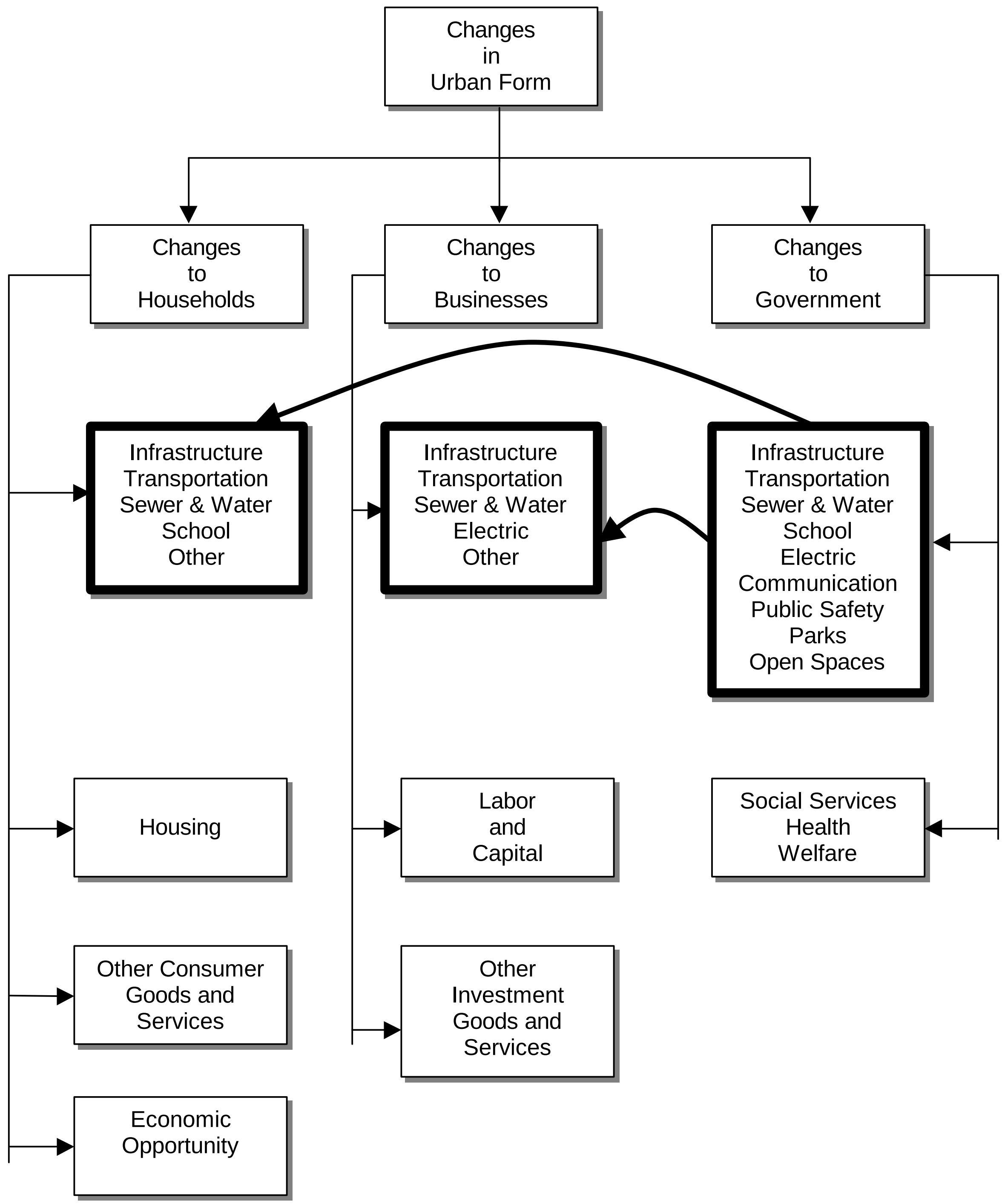
Note that a key advantage of looking at the intermediate, derived demand is that, under some reasonable simplifying assumptions, one does not have to then look at the market for every good and service traded in the metropolitan region. For example, one does not have to estimate how urban form changes the price of bread, but rather how it changes the price of buildings and electricity to make it, or the price of transportation to import it or deliver it. The exceptions would be externalities in final markets: e.g., if urban form were to produce lower service costs for certain producers that did significant environmental damage, thus increasing their output and their damage. Looking at infrastructure cost and effectiveness is also key because infrastructure has direct links to many things people are concerned about when they talk about environmental quality, livability, and quality of life.

Our conclusion is that the impacts of changes in urban form on the cost of infrastructure is probably the single most important impact to evaluate. In that sense, there is a good argument for working with Figure 3.

That approach, with infrastructure as the sole concern, does not cover everything, either technically or politically. A full-cost framework must also consider secondary effects, may of which are external and are without immediate market prices to quantify their value. For example, some households will find changes in urban form also change the amount of noise they are subjected to, the aesthetic appeal of their neighborhood or larger community, or their feeling of connection with the community. Air quality impacts in most cases are primarily the result of automobile emissions in most metropolitan areas. Unlike for water quality, metropolitan areas do not investment in “air quality treatment” plants. Thus, infrastructure is not directed at mitigating air quality problems.[16]

[16] Changes in urban form may, of course, change the demand for different modes of transportation and affect air quality.

Figure 3: Markets Where Policies to Change Urban Form are Likely to Have Direct (Internalized) Effects on Prices



Similarly, changes in urban form can impact the supply and cost of consumer goods not only through the cost of infrastructure (primarily, transportation, sewer, water, and electricity), but indirectly through economies of agglomeration or scale they may produce for business.

Several researchers of metropolitan areas have argued that major problems in our central cities are a result of socioeconomic forces that are abetted by urban form and capital investment. (Orfield 1995; Rusk 1993). If cities try to redress those impacts with social programs, then it is not too much of a stretch to attribute, at least in theory, some part of those program costs to urban form.

Figure 3, as complicated as it is, is static. It does nothing to capture the dynamics of economic change, land development, markets, and public policy in a metropolitan area.

We have described several options for organizing a full-cost framework for thinking about the benefits and costs of changes in urban form. All of the options, as complicated as they may seem, are static. They do nothing to capture the dynamics of economic change, land development, markets, and public policy in a metropolitan area.

Lastly, it is important to remember the issue of double-counting. Since a fully developed framework will almost always introduce this possibility, it is essential that researchers apply a simple, common sense test to any category of impacts which is to be introduced into an analysis of these issues. There is no way in which one can insure the absence of double-counting except through the application of diligence and common sense.

However, as a reasonable basis for an accounting framework, Figure 3 is appropriate and useful.

As we move into the next chapter of this report, we will present the literature describing the impacts of alternative development patterns, with this framework and set of issues in mind.

3.0 LITERATURE SYNTHESIS OF THE COSTS AND BENEFITS OF ALTERNATIVE DEVELOPMENT PATTERNS[17]

3.1 OVERVIEW

The purpose of this chapter is to summarize the state of knowledge about the impacts of alternative urban forms and development patterns. The frameworks we developed and evaluated in the last chapter are suggestive of the breadth of these impacts. In this chapter, we summarize what is known about the major categories of impacts.

Much of the literature on the impacts of alternative development patterns has been cast in terms of the impacts of "sprawl." Sprawl refers to a particular type of suburban peripheral growth. It refers to development that expands in an *unlimited and noncontiguous (leapfrog) way outward* from the solidly built-up core of a metropolitan area. In terms of land-use coverage, sprawl includes both *residential and nonresidential development.* Residential development contains primarily single-family housing, including significant numbers of distant units scattered in outlying areas. Nonresidential development includes shopping centers, strip retail outlets along arterial roads, industrial and office parks, freestanding industrial and office buildings, as well as schools and other public buildings.

These different types of land uses are, for the most part, *spatially segregated* from one another. The components of this development are individually located in small subdivisions in zoning districts. Within each district, usually only one type of use is permitted—e.g., single-family residential, shopping centers, strip commercial, industrial, or office parks.

Another of sprawl's distinguishing traits is its *consumption of exurban agricultural and other frail lands* in abundance; these are the types of land found at the periphery of development. The loss of agricultural acreage takes place in abundance because it often is the cheapest land available for development. Fragile environmental lands are swallowed up because they are part of the otherwise developable tracts. These tracts would not be developed if the environment was adequately protected.

Under sprawl conditions, there is almost total *reliance upon the automobile* as a means of accessing the individual land uses. Seventy years ago, the streetcar was the most popular form of transportation to the suburbs. Nowadays the automobile is the most efficient means of accessing sprawl's outward extension and skipped-over development. For seven-day-a-week business and recreational use, including both at-peak and off-peak use, nothing can match the automobile for cost, efficiency and versatility—at least in the short term.

[17] This Chapter is excerpted from a work in progress for TCRP H-1 "The Costs of Sprawl — Revisited". Dr. Robert Burchell is the Principal Investigator; Sam Seskin and Terry Moore are members of the research team.

The automobile has replaced the streetcar, stimulating sprawl development.
Source: Peter Muller, *The Geography of Urban Transportation.*

In this chapter, we use sprawl as a heading under which we can organize and review a variety of published literature on the impacts of development. Sprawl is by no means the only possible settlement pattern, though it is, following the definition we have just given, a nearly ubiquitous one. Because sprawl is commonly defined in terms to which most people can relate, and it is widely evident, it serves as a convenient organizing principle under which we will conduct this literature review.

The "costs" of sprawl have been talked about for decades, often without a full understanding of what these costs are, and to what level they should be assigned. For our purposes, the "costs" of sprawl are the resources expended relative to a type, density, and/or location of development. These "costs" involve *physical, monetary, temporal, and social/psychological* resources, as explained in Chapter 2. They involve costs to the individual, to the community, and to society. Most of the costs specified to date are physical or monetary, although occasionally social costs (e.g., the loss of upward mobility) or psychological costs (e.g., the loss of sense of community) are documented.

The "benefits" of sprawl are mirror images of costs. They involve resource gains due to type of development pattern and include similar categories of gain as those of losses stated above. This might involve a temporal gain in suburb-to-suburb travel time because most residences and jobs are now both suburban, or monetary gains due to reduced housing costs also from building farther out, or social gains such as the ability to achieve home ownership, again due to location in more distant places.

In the pages which follow, costs and benefits are reported in the form that the primary research provides.

By choosing to organize this literature around "sprawl" we are for the moment side stepping the possible need to define specific alternative development patterns to the ones outlined above. In Chapter 4, we will return to the analysis of alternatives of development patterns, and we will introduce an application of the accounting framework presented in Chapter 2 which breaks down alternative development patterns and urban form into constituent elements, identifies the nature of costs associated with each, provides preliminary illustrative estimates of many of these costs, and adds and compares them. In that chapter we will see once again how it is possible to consider alternatives to "sprawl" as well as to track their costs and impacts.

But, in this chapter, our goal is to survey the literature through the best lens we have available; that lens is "the cost of sprawl."

3.2 ANALYSIS OF THE LITERATURE ON THE COSTS AND BENEFITS OF ALTERNATIVE DEVELOPMENT PATTERNS

A search of the literature reveals that various commentators have attributed over two dozen negative and over one dozen positive impacts to alternative development patterns. These impacts are set forth in Figure 4. The list is not a scientific taxonomy; it does not include all the alleged effects of alternative development patterns. Rather, in the judgment of those reviewing the literature, it includes some of the most significant impacts. Further, not all of the allegations can be substantiated; nor are they of equal importance. However, this inventory presents a comprehensive set of allegations based on the relevant literature summarized here.

The allegations have been classified into five substantive categories:

1) Public-private capital and operating costs;
2) Transportation and travel costs;
3) Land and natural habitat preservation;
4) Quality of life; and
5) Social issues.

Each of the alleged negative and positive impacts found in the literature search under these five substantive groupings is examined in depth following a common presentation format as follows:

1) *Topic*. What is the specific subject matter of the alleged cost or benefit?

2) *Allegation/Basis*. Synopsis of the alleged cost or benefit and the basis or logic of the supposed effect.

3) *Literature Synthesis*. Pertinent studies on the allegation are cited, either supporting or rebutting it. The presentation of the literature synthesis is accomplished using both text and a matrix. The matrix distinguishes:

   c) Whether or not the alleged factual condition exists under conditions of alternative development patterns (or more generally whether development pattern affects the item in question.)

   b) Whether or not the alleged factual condition—if it exists—has been significantly linked to alternative development patterns (i.e., to development pattern).

Figure 4: Alleged Negative and Positive Impacts of Sprawl

Substantive Concern	***A. Alleged Negative Impacts***	***B. Alleged Positive Impacts***
I. Public-Private Capital and Operating Costs	1. Higher infrastructure costs 2. Higher public operating costs 3. More expensive private residential and nonresidential development costs 4. More adverse public fiscal impacts 5. Higher aggregate land costs	1. Lower public operating costs 2. Less expensive private residential and nonresidential development costs 3. Fosters efficient development of "leapfrogged" areas
II. Transportation and Travel Costs	1. More vehicle miles traveled (VMT) 2. Longer travel times 3. More automobile trips 4. Higher household transportation spending 5. Less cost-efficient and effective transit 6. Higher social costs of travel	1. Shorter commuting times 2. Less congestion 3. Lower governmental costs for transportation 4. Automobiles most efficient mode of transportation
III. Land/Natural Habitat Preservation	1. Loss of agricultural land 2. Reduced farmland productivity 3. Reduced farmland viability (water constraints) 4. Loss of fragile environmental lands 5. Reduced regional open space	1. Enhanced personal and public open space
IV. Quality of Life	1. Aesthetically displeasing 2. Weakened sense of community 3. Greater stress 4. Higher energy consumption 5. More air pollution 6. Lessened historic preservation	1. Preference for low-density living 2. Lower crime rates 3. Reduced costs of public and private goods 4. Fosters greater economic well-being
V. Social Issues	1. Fosters suburban exclusion 2. Fosters spatial mismatch 3. Fosters residential segregation 4. Worsens city fiscal stress 5. Worsens inner-city deterioration	1. Fosters home rule 2. Enhances municipal diversity and choice

This matrix is not a rigorous measuring instrument. It could have been produced in a variety of ways. Even as currently structured, there is not always consensus among the authors on how to “score” an item—i.e., whether there is “general agreement” or “some agreement” in the literature. For that matter, there is not always consensus on how convincing the literature is in its relationship of development impacts to alternative development patterns.

The purpose of the matrix and the accompanying discussion is to synthesize in a systematic way, the important studies on alternative development patterns. This effort identifies what researchers on the subject have considered and debated; what data have been used and how the data have been analyzed; where the gaps in the state of knowledge are. The detailed literature summary begins with the first allegation in the first category.

3.3 PUBLIC AND PRIVATE CAPITAL AND OPERATING COSTS

I.A. Sprawl’s Alleged Negative Impacts

I.A.1. Higher Infrastructure Costs

Allegation/Basis

Infrastructure of a wide scope—e.g., local and regional roads, water and sewer systems, and schools—is more expensive under sprawl than under compact development. This allegation alludes to infrastructure that is primarily public (i.e., state, county, or local government roads; public utility systems; and public schools) and occasionally private (i.e., privately owned utility systems and subdivision-level roads that are not dedicated to the public sector).

Literature Synthesis

As shown in Figure 5, *The Costs of Sprawl* (RERC 1974a) found that capital costs per unit were higher in the “low-diversity sprawl” and “sprawl mix” neighborhood prototypes than they were in the “planned mix” or “high-density planned mix” prototypes. *The Costs of Sprawl* also found that capital expenses per unit were higher in detached housing (more pronounced under sprawl) than they were in attached housing (more pronounced under compact development). The first finding of *The Costs of Sprawl,* although criticized, has basically stood the test of time (Altshuler 1977); the second finding proved to be the undoing of the study (Windsor 1979).

Figure 5: Real Estate Research Corporation (RERC 1974a)
The Costs of Sprawl: Summary of Findings

Category	*Community Prototypes (10,000 units)*					*Neighborhood Prototypes (1,000 units)*				
	Low-density Sprawl	*Low-density Planned*	*Sprawl Mix*	*Planned Mix*	*High-density Planned*	*Single-family Conventional*	*Single-family Clustered*	*Townhouse Clustered*	*Walk-up Apartment*	*High-rise Apartment*
INFRASTRUCTURE	*Capital costs per unit*									
Recreation	$ 268	$ 297	$ 268	$ 297	$ 297	$ 220	$ 274	$ 274	$ 252	$ 203
Schools	4,538	4,538	4,538	4,538	4,538	5,354	5,354	4,538	4,538	1,646
Public Facilities	1,662	1,626	1,645	1,622	1,630					
Roads/streets	3,797	3,377	3,235	2,708	2,286	3,080	2,661	2,111	1,464	801
Utilities	6,197	4,744	3,868	3,323	2,243	5,483	3,649	2,369	1,579	958
Infrastructure Subtotal	16,462	14,582	13,556	12,487	10,995	14,137	11,938	9,292	7,833	3,628
Construction/Other[a]	34,994	34,398	23,728	23,266	17,711	34,774	34,320	17,967	13,449	17,088
Total Unit Costs	$ 51,456	$48,981	$ 37,283	$ 35,753	$28,706	$ 48,911	$ 46,258	$ 27,259	$ 21,282	$ 20,696
Public Proportion	19%	12%	24%	16%	18%	15%	15%	20%	25%	13%
Public Costs	$ 9,777	$5,878	$ 8,948	$ 5,720	$5,167	$ 7,337	$ 6,939	$ 5,452	$ 5,321	$ 2,690
OPERATING	*Annual Non-residential Operating and Maintenance Costs per Unit (in year 10)*									
Operating Costs	$ 2,111	$2,067	$ 1,965	$ 1,937	$1,873	$ 1,721	$ 1,720	$ 1,388	$ 1,319	$ 548
Public Proportion	57%	51%	61$	55%	55%	67%	67%	72%	74%	57%
Public Costs	$ 1,203	$1,054	$ 1,199	$ 1,065	$1,030	$ 1,153	$ 1,152	$ 999	$ 976	$ 312
LAND	*Land Required (for 10,000 units)*									
Total Acres	NA	NA	NA	NA	NA	5000	4000	3000	2000	1000
Developed Acres	4,590	4,113	2,780	3,040	2,173	NA	NA	NA	NA	NA
Vacant, Improved Acres	459	206	278	152	109	NA	NA	NA	NA	NA
Vacant, Semi-improved Acres	951	617	1,390	456	326	NA	NA	NA	NA	NA
Vacant, Unimproved Acres	—	1,064	1,552	2,352	3,392	NA	NA	NA	NA	NA
Total Vacant Acres	1,410	1,887	3,220	2,960	3,827	NA	NA	NA	NA	NA
ENVIRONMENT	*Principal Environmental Impacts (for 10,000 units)*									
Non-auto Air Pollutants[b]	1,420	1,420	1,034	1,034	809	1,420	1,420	951	738	644
Sewage Effluent[c]	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Water Use[d]	1,170	1,100	910	910	760	1,205	1,059	913	730	639
Non-auto Energy Use[e]	2,355	2,355	1,750	1,750	1,400	2,398	2,398	1,595	1,232	1,056

Frank (1989) reanalyzed (using current cost numbers) several studies conducted between the 1950s and the 1980s that examined relationships between land use and infrastructure costs (including *The Costs of Sprawl)*. Accounting for the limitations of *The Costs of Sprawl* study, he concluded that infrastructure costs were *highest* in situations of low density and for development located a considerable distance from centralized public services (conditions of sprawl). Infrastructure costs were *lowest* in situations of higher density and for development that was centrally and/or contiguously located (conditions of compact development). Duncan (1989) analyzed the infrastructure costs of multiple Florida residential and nonresidential developments with varying patterns of development. Costs were *higher* for those with *sprawl* characteristics than they were for those with compact development characteristics (see Figure 7).

Infrastructure costs were highest in situations of low density and for development located a considerable distance from centralized public services.

The longest run modeling of infrastructure costs under different development scenarios was performed by Burchell et al. (1992-1997) in New Jersey and in other locations. The infrastructure models applied by Burchell relate development density and housing type to the demand for local/state roads and water/sewer infrastructure. The studies found that the *amount of land consumed* for development was *directly* related to lane miles of road required for two-lane (local) and four-lane (state) roads. Thus, *density* of development was found to be *inversely* related to lane miles of local and state roads and their attendant infrastructure costs. Housing type and, to a lesser extent, density were related to the amount of water and sewer services consumed (measured in gallons) by development. Almost all of the difference in residential water usage related to whether or not occupants of residential and nonresidential facilities watered their lawns. Lawn watering takes place primarily in single-family detached residences and high-value research and commercial headquarters uses. The difference in water usage among various commercial and industrial uses is also related to the service or product that is generated by the facility.

Figure 6: Duncan (1989) - Florida Growth Pattern Study: Capital Facility Costs Under Sprawl Versus Compact Development

(per dwelling unit; 1990 dollars)

Category of Capital Costs	Average of Case Studies under Sprawl Development[1]	Average of Case Studies under Compact Development[2]	Sprawl Versus Compact Development *Difference*	*# / %*
Roads	$ 7,014	$ 2,784	(+) $4,230	60.3
Schools	6,079	5,625	(+) 454	7.4
Utilities	2,187	1,320	(+) 867	39.6
Other	661	672	(–) 11	1.7
TOTAL	$15,941	$10,401	(+) $5,540	36.7

Notes: 1. Sprawl development as defined here include the following patterns of "urban form" analyzed by the Florida study: "scattered," "linear," and "satellite." The capital cost figures shown in this table are averages of the Florida case studies characterized by the scattered, linear, and satellite patterns (i.e., Kendall Drive, Tampa Palms, University Boulevard, and Cantonment).

2. Compact development as defined here includes the following patterns of "urban form" analyzed by the Florida study: "contiguous" and "compact." The capital cost figures shown in this table are averages of the Florida case studies characterized by the contiguous and compact patterns (i.e., Countryside, Downtown Orlando, and Southpoint.)

Source: Memorandum from James Duncan and Associates to Robert W. Burchell and David Listokin, May 8,1990; and James Duncan et al., *The Search for Efficient Urban Growth Patterns.* Report prepared for the Governor's Task Force on Urban Growth Patterns and the Florida Department of Community Affairs (Tallahassee, July 1989).

Larger and more significant than water/sewer usage are differences observed in water/sewer *infrastructure*, particularly as related to the number of feeder hookups from the trunk line that an individual land use requires. Higher density, the clustering of land uses, and attached housing and linked nonresidential uses all contribute to a reduced number of infrastructure feeder lines and reduced costs. A model sensitive to these differences, applied in New Jersey to alternative growth scenarios differentiated by sprawl-like versus more compact development patterns, showed the former's infrastructure costs to be considerably higher. The findings were basically similar in order of magnitude across most of the other locations analyzed by Burchell et. al. (Burchell and Listokin 1995a) (see earlier Figures 4 and 5). The findings were also comparable to those arrived at by Frank (1989) and Duncan (1989) in their studies (see Figure 7).

Figure 7: Relative Infrastructure Costs of Sprawl Versus Compact Development From Three Major Studies

		Compact Development Costs as Percent of Sprawl Development Costs: Findings from Three Major Studies			
Infrastructure Cost Category	Sprawl Development	Duncan Study (1989)	Frank Study (1989)	Burchell Studies (1992-1997)	Compact Development Costs: Synthesis from Three Major Studies (in percent, relative to sprawl)
Roads (local)	100%	40%	73%	74-88%	≈75%
Schools	100%	93%	99%	97%	≈95%
Utilities	100%	60%	66%	86-93%	≈80%

Source: Burchell and Listokin (1995) and Table 4

Other relevant research indicating higher infrastructure costs under conditions of sprawl includes Archer (1973) and Duensing (1977). Base data on infrastructure and its costs, not related to development pattern, such as average capital outlays per single-family house or costs per linear foot of roadway, are provided by Fodor (1995), Nichols et al. (1991), Nelson (1988), FACIR (1986), and OP&R (1982).

The above body of research which reflects, in part, an approach dating back to *The Costs of Sprawl*, has been criticized on several counts by Altshuler (1977) and Altshuler and Gomez-Ibanez (1993) for the following reasons:

1) The higher infrastructure costs found in instances of lower versus higher density (i.e., sprawl versus compact development) is not meaningful because the housing units and their attendant scale found under the different development alternatives (i.e., more detached housing under sprawl and more attached housing under compact development) are not comparable.

2) The higher infrastructure costs attributed to sprawl due to its leapfrog patterns will essentially be neutralized as areas that were initially passed over are ultimately developed.

3) The higher infrastructure costs (under sprawl) attributed to the distance of development from central facilities does not consider potential economies of scale that could be realized in regionalized, oversized trunk lines or similarly located water/sewer treatment plants (Altshuler and Gomez-Ibanez 1993).

Holding aside the above criticisms, at least one researcher, Richard Peiser, finds the cost difference in infrastructure between sprawl and compact development patterns to be quite slight. Peiser (1984) examined infrastructure costs for new residential development in two Texas “prototype” communities—one planned, the other unplanned. The planned and unplanned developments were located on 7,500-acre sites in Houston. The planned community was designed to accommodate a population of about 80,000 residents in 26,500 dwelling units and a workforce of 72,000 in 24 million square feet of office and industrial space. The development was largely self-contained and near existing development in the form of a large center. The unplanned development was located in a primary growth corridor at the urban fringe, typical of Houston’s sprawl pattern (100- to 500-acre subdivisions, strip malls, and shopping centers). The Houston development was designed to accommodate about the same number of residents (80,000) and workers (72,000) as the planned development. In Peiser’s model, the difference in capital expenses for the planned and unplanned scenarios was about 5 percent in favor of the planned development. The finding in the Peiser study that contradicts other findings in the field was the inclusion in overall planned development infrastructure savings of higher road costs associated with planned as opposed to unplanned development (Figure 8).

In sum, although, there is general agreement that development density is linked to infrastructure costs, there is less agreement about the interrelationship between sprawl (as a less carefully defined development form) and infrastructure costs.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?	X			
Is it strongly linked to sprawl?		X		

Figure 8: Infrastructure Costs for Planned and Unplanned Development
The Peiser Model

Infrastructure Costs Component	Planned Development (for 80,000 residents) ($ in millions)	Unplanned Development (for 80,000 residents) ($ in millions)
Roads	$10.0	$8.0
Sewer	4.3	4.7
Water	9.2	11.8
Drainage	16.3	17.4
TOTAL	$39.8	$41.9

Source: Richard B. Peiser 1984

I.A.2. Higher Public Operating Costs

Allegation/Basis

Sprawl generates greater local/school district operating costs than higher density forms of development. This allegation relates to splintered public local and educational agencies that provide duplicative administrative and operating services.

Literature Synthesis

Generally speaking, per capita *local* costs are "U" shaped as a function of population size—i.e., they are expensive for jurisdictions with populations under 2,500 and over 50,000, with points of most efficiency in those locations where the population is between 10,000 and 25,000. School district per pupil costs increase with school district size. Districts with more than 3,000 pupils spend 20 to 30 percent more per pupil than districts of fewer than 1,000 pupils; districts of 1,000-3,000 pupils spend 10 percent more than districts of fewer than 1,000 pupils (Sternlieb and Burchell 1975; Burchell and Listokin 1996).

Both local (municipal and county) public service costs per capita and school district public service costs per pupil also vary directly with the wealth of the jurisdiction. The citizens of wealthier jurisdictions demand greater qualities and quantities of local and educational public services and are willing to pay for them (Burchell and Listokin 1996).

Per capita local and school district costs also have been found to vary directly with density, and inversely with the growth rate of the jurisdiction. Generally speaking, the higher the density, the higher the per capita and per pupil costs; the faster the growth rate, the lower the per capita and per pupil costs (Ladd 1992). Two caveats are noteworthy, however. First, comparisons almost always are made between suburban- and urban-level densities and rarely between densities that reflect more versus less intense suburban development. Second, none of the analyses performed to date standardize the quality or quantity of public services delivered (Altshuler and Gomez-Ibanez 1993).

Thus, buried in the above findings is the fact that public services that are delivered in very large and dense local (municipal and county) jurisdictions are more complex and more individualized than those delivered in smaller, more sparsely populated jurisdictions. Foot patrol or two-person automobile police patrol takes the place of one-person automobile police patrol; full-time paid fire department employees take the place of volunteers; and significant numbers of special education teachers must be hired instead of contracting out special education services. All these examples point to the service differences that complicate comparison of costs in more intensely populated versus less intensely populated jurisdictions.

Local government costs nationally average about $700 per capita; school district costs average about $7,000 per pupil (*Census of Governments* 1992). Of the former, about 60 percent goes toward salaries and benefits, 35 percent toward other expenses, and 5 percent toward capital purposes. Of the latter, 70 percent goes toward salary and benefits, 20 percent toward other expenses, and 10 percent toward capital purposes.

Compact or managed growth, the opposite of sprawl development, may encourage more regionalism in school systems and more sharing of non-police local public resources. It also reduces the amount of local roads and water/sewer utility lines and hook-ups that are *constructed* and paid for by local debt service and *maintained* and paid for out of annual operating budgets.

Burchell, in his analysis of the growth alternatives in the *Impact Assessment of the New Jersey State Development and Redevelopment Plan*, found that combined municipal and school district operational costs could be reduced by 2 percent annually under planned (compact) growth, as opposed to trend (sprawl) growth (Burchell 1992a). Although the percentage seems small, the savings occur annually; they are not a one-time windfall, and the savings could potentially be applied nationally to local budgets that sum to $175 billion per year, and to school district budgets that sum nationally to $500 billion annually.

In similar type studies in the Delaware Estuary, and in the state of Michigan, municipal costs were found to be 5-6 percent less annually under compact growth scenarios than they were under sprawl development.

Basically equivalent findings were also arrived at by James Duncan in Florida (Duncan 1989). Conflicting findings have been suggested, but not empirically tested, by Altshuler and Gomez-Ibanez (1993) and Gordon and Richardson (1997). Altshuler and Gomez-Ibanez indicate that the inability to control for the quality and quantity of services under comparison renders most of these studies at best “time and location bound” by who is providing the services, the types of public services, and when they are provided. At worst, most of the studies cannot be used to draw appropriate conclusions, given their inability to differentiate between levels of service provided (Altshuler and Gomez-Ibanez 1993).

Gordon and Richardson indicate that Burchell’s prospective alternative development scenarios allow no flexibility for the trend (sprawl) scenario to improve over time and no flexibility for the plan (compact growth) scenario to be worse than envisioned due to the lack of full compliance with this alternative (Gordon and Richardson 1997).

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

I.A.3. More Expensive Private Residential and Nonresidential Development Costs

Allegation/Basis

Sprawl causes residential and nonresidential building and occupancy costs to rise due to the larger lot and structure sizes in locations where land is less expensive.

Literature Synthesis

Development costs include land and improvement costs, and are impacted by the scale of each. Spacious single-family dwellings on large lots are usually the most expensive types of housing; similarly, spread-out, low-rise nonresidential development on large parcels of land are the most expensive type of commercial and/or industrial development. Both are low-density examples of their respective development forms.

Other factors that affect the costs of residential and nonresidential development include: 1) the amount of zoned land available for development, as determined by the local zoning ordinance; and 2) the time it takes development to engage and clear the permitting process—(which is, also largely determined by local land-use regulations). If land is limited or inappropriately zoned, residential and nonresidential development costs will rise. If government regulations are excessive, permitting time will increase; and the costs of development will also rise.

In the *Impact Assessment of the New Jersey State Development and Redevelopment Plan* (1992a), Burchell found that if new development is contained around existing development and is also increased somewhat in terms of density and floor-area ratio, that even with significant decreases in density to preserve lands at the periphery, overall residential and nonresidential development costs will be approximately 10 percent less per unit or per 1,000 square feet. Somewhat less savings (6-8%) emerged from studies conducted by Burchell in Lexington, Kentucky (1994b), the Delaware Estuary (1995), and the state of Michigan (1997a).

Other studies of residential development have produced essentially parallel findings on the effects of increased lot and structure size on housing costs. Seidel (1978), Downs (1973), Schafer (1975), and others have found that large-lot zoning and minimum building size increase the costs of new housing. This same type of analysis applied to nonresidential development—although not often looked at by researchers in the field—has produced similar findings (Burchell et al. 1992-1997).

Some researchers have found that large-lot single-family zoning and minimum building sizes are associated with sprawl development. Smaller lot sizes (zero lot line) and different types and intensities of development (single-family attached and multifamily) are associated with compact development (CH2M Hill 1994 and Avin 1996). Linking the above two sets of findings, the savings noted by housing type should then extend to these two polar development forms.

One cannot assume, however, that housing preference changes will accompany development pattern shifts. In other words, if compact development is opted for, and denser forms of housing comprise this type of development, it cannot be assumed that market preferences will correspondingly shift and families previously occupying less dense types of housing under sprawl will opt for the more intense development forms under compact development. Further, if there is a crossover between housing types, one must carry the occupancy profile of the former to the new type of housing unit. Otherwise, false conclusions could be drawn with regard to development cost savings associated with the often smaller, and less intensely occupied housing of compact development, and with the annual fiscal impact savings resulting from this development form. A critical error was discovered by Windsor in his review of *The Costs of Sprawl* (Windsor 1979). According to Windsor, *The Costs of Sprawl* study failed to account for the fact that the characteristics of new townhouse occupants who switched from detached single-family occupancy (if they could be assumed to do so) would be closer to the characteristics of occupants of the units that they had left than to the characteristics of the occupants of units similar to their new housing. This lack of realization led to the erroneous conclusion that compact development (containing a larger percentage of townhouses) was less expensive to service than sprawl development (containing a larger percentage of single-family homes), when the same households that occupied the former would undoubtedly be the ones moving to the latter.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

I.A.4. More Adverse Public Fiscal Impacts

Allegation/Basis

Sprawl generates more adverse fiscal impacts than compact development because public operating costs are significantly higher and residential uses and attendant revenues do not compensate for these costs. Further, fragmented governments compete for land uses according to these land uses' fiscal superiority. Most "good" (from a local fiscal impact perspective) economic uses have been withdrawn from central cities and transplanted to suburban jurisdictions. Since, there are not enough "good" land uses to go around, only the wealthiest jurisdictions truly benefit fiscally from these land uses.

Literature Synthesis

In analyzing the impacts of land uses, the notion that some types of land uses are better fiscally than others, has become widely accepted. Nonresidential land uses, for the most part, have been shown to be more profitable; than residential uses; and most standard forms of residential land uses, less profitable (see Figure 9). Further, within the nonresidential and residential sectors, varying degrees of advantage and disadvantage exist. Some land uses produce more revenues than costs; if service levels are maintained at the same level after development, taxes could be decreased. The reverse is also true. In some cases, costs exceed revenues and, all things being equal, taxes might have to be increased (Burchell and Listokin 1994a).

Burchell's *Impact Assessment of the New Jersey State Development and Redevelopment Plan* (Burchell et al. 1992a) employed a fiscal model to view the effects of trend versus planned development. The Rutgers fiscal impact model estimated the number of people, employees, and students that were generated under each of the development scenarios and projected their future costs and revenues to host public service jurisdictions. Although at the regional and state levels, population and employment projections did not vary between alternatives, at the municipal level the differences were significant. In the compact development case, urban communities with slack service capacity received more growth than rural areas with lesser amounts of public service infrastructure. The reduced infrastructure provision and potentially reduced annual maintenance on this infrastructure, led to diminished fiscal impacts for this alternative.

Figure 9: The Hierarchy of Land uses and Fiscal Impacts

(+) **MUNICIPAL BREAK EVEN**	Research Office Parks Office Parks Industrial Development High-Rise/Garden Apartments *(Studio/1 Bedroom)* Age-Restricted Housing Garden Condominiums *(1-2 Bedrooms)* Open Space	
	Retail Facilities *Townhouses* *(2-3 Bedrooms)* Expensive Single-family homes *(3-4 Bedrooms)*	**(+)** **SCHOOL DISTRICT BREAK EVEN**
	Townhouses *(3-4 Bedrooms)* Inexpensive Single-family Homes *(3-4 Bedrooms)* Garden Apartments *(3+ Bedrooms)* Mobile homes *(Unrestricted as to occupancy locally)*	**(-)**

Note: The above list contains too many disclaimers to include here. Suffice it to say that specific fiscal impacts of a land use must always be viewed in the context of other land uses' impacts and within the fiscal parameters of the jurisdiction in which the land use is being developed.

Source: Burchell, Robert W. and David Listokin, "Fiscal Impact Analysis: State of the Art and State of the Practice

Burchell's study in New Jersey found that:

> By containing population and jobs in already developed areas and by creating or expanding centers in newly developing areas, the State Plan offers an annual $112 million [or 2 percent] fiscal advantage to municipalities. This advantage reflects the ability under plan to draw on usable excess operating capacity in already developed areas as well as efficiencies of service delivery. For instance, fewer lane-miles of local roads will have to be built under plan, thus saving municipal public works maintenance and debt service costs. Public school districts will realize a $286 million [or 2 percent] annual financial advantage under the State Plan, again a reflection of drawing on usable excess public school operating capacity and other service and fiscal efficiencies realized due to the redirection of population under the plan alternative. Thus, municipal and school district providers of public services could be ahead fiscally by close to $400 million annually under plan compared to trend, while meeting similar population demands for public services.
>
> Under trend, the state's school districts will have to provide 288,000 net pupil spaces to the year 2010 (365,000 gross need less 77,000 usable excess spaces); for plan, the net need is lower at 278,000 pupil spaces based on excess space available in central cities. Overall, if new space had to be built to accommodate net new students, costs of new school facilities would be approximately $5.3 billion under trend and $5.1 billion under plan. Thus, $200 million [or approximately 3 percent] is potentially saved due to more excess capacity in closer-in areas being drawn upon by plan as opposed to lesser amounts of excess capacity available to trend in suburban and rural areas (Burchell et al. 1992a).

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?		X		

I.A.5. Higher Aggregate Land Costs

Allegation/Basis

Total land costs of urban settlements are higher under sprawl. This occurs even though the average price of land per acre may be lower, because a given total population occupies more suburban land than under higher density urban forms of growth.

Literature Synthesis

Most of the modeling efforts to date that involve prospective development futures have found that alternatives to "status quo" development patterns (i.e., sprawl), consume less overall land than the sprawl development pattern does. In New Jersey, Lexington, Kentucky, the Delaware

Estuary, and Michigan, alternatives to sprawl consumed 20-40 percent less overall land (Burchell 1992-1997). In the San Francisco Bay area, alternatives to sprawl consumed 10-25 percent less overall land than did sprawl (Landis 1995). Thus, land consumed under sprawl has almost always been shown to be more than land consumed under compact growth patterns.

Further, in the Burchell (1992-1997) studies because densities were increased to design levels under compact growth, housing costs decreased as a result of the reduction in land costs associated with this alternative. In other words, in situations where there were no growth restrictions, housing costs were higher under sprawl because land costs were higher.

Land consumed under sprawl has almost always been shown to be more than land consumed under compact growth patterns.

In the above four Burchell study locations, for example, housing costs under sprawl development were more due to the land component of these costs. This was true because under compact development, the majority of development taking place closer-in was subject to density increases of 10 to 30 percent. Total land costs of urban settlements have been found to be generally higher under the sprawl alternative (see Negative Land/Natural Habitat section).

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?		X		

I.B. Sprawl's Alleged Positive Impacts

I.B.1. Lower Public Operating Costs

Allegation/Basis

Local and school district operating costs are lower under sprawl development because service demands and the costs of meeting these demands increase with higher densities (compact development).

Literature Synthesis

Gordon and Richardson express this argument, citing the research of Ladd:

> Ladd (1992) argued that except within a range of very low densities, per capita public service costs for traffic management, waste collection and disposal, and crime control, increase with higher densities (Gordon and Richardson 1997, 99).

Again, this is the type of research that has not standardized for the quality and quantity of public services delivered in jurisdictions of varying densities. Nonetheless, the above research indicates that without taking into account what services are delivered or who delivers them in a service district—operating costs, whatever they are comprised of, appear to be less in jurisdictions of low density than in jurisdictions of high density.

Operating costs appear to be less in jurisdictions of low density than in jurisdictions of high density.

However, comparisons of operating costs are usually made between locations of rural-suburban (1 to 3 units per acre) density and those of urban density (16 to 30 or more units per acre). These studies may well be measuring the differences in range and complexity of public services delivered in densely populated urban areas versus rural-suburban areas, where the public services delivered are very limited and much simpler (see Operating Costs in the Negative Impacts section).

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

I.B.2. Less Expensive Private Residential and Nonresidential Development Costs

Allegation/Basis

Sprawl has lower housing costs because it does not limit the amount of development. Many managed approaches to growth seek also to control growth. Various forms of growth control limit housing production and drive up the costs of housing.

Literature Synthesis

Does the overlay of regulations inherent in managed growth, drive up the cost of housing? A number of studies reveal that in the immediate area where growth restrictions exist, housing prices increase (Fischel 1990). Schwartz, Hansen, and Green (1981) followed the effects over time of the Petaluma (California) Plan which severely limited building permits, favoring dwellings with costly design features and developer-provided amenities and services to the community. Using a statistical (i.e., hedonic) pricing technique, the authors compared the price of a standard bundle of housing characteristics to the corresponding price in nearby Santa Rosa, which had not adopted growth controls during the period. The authors found that after several years, Petaluma’s housing prices had risen 8 percent above those of Santa Rosa.

Schwartz, Zorn, and Hansen (1989) did a similar study of the growth controls in Davis, California, comparing house prices in Davis to those in a sample of other Sacramento suburbs.

They found that growth controls caused house prices in Davis to be nine percent higher in 1980 than they would have been without them.

In Petaluma (Schwartz, Hansen, and Green 1981) and in Davis (Schwartz, Zorn, and Hansen 1989), the effects on the housing stock affordable to low- and moderate-income households relative to control areas were also monitored. In Petaluma, the authors found that the percentage of the housing stock that was affordable to low- and moderate-income households dropped significantly below that of a control group (Fischel 1990).

Where growth is controlled as opposed to managed, housing costs are higher.

In Davis, on the other hand, growth controls required those who received building permits to construct some units earmarked for low-income occupants. Thus, the limited growth that did occur in Davis contained both low-income and high-income housing. According to Fischel (1990), however, an unanticipated offset to this apparent success occurred; the existing housing in Davis increased not only in price but in quality. Fischel’s interpretation of this outcome was that older housing was filtering up rather than down.

Katz and Rosen (1987) analyzed 1,600 sales transactions of single-family houses during 1979 in 64 communities in the San Francisco Bay Area. Of these transactions, 179 involved houses located in communities where a building permit moratorium or binding rationing system had been recently or was currently in effect. According to Fischel (1990), this study is particularly valuable since, unlike the other California studies, it did not focus on just a single community. The authors found that the price of houses sold in the growth-controlled communities was *higher* than the price of houses sold in other communities. Where growth is *controlled* as opposed to *managed*, housing costs are higher.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?		X		

I.B.3. Fosters Efficient Development of “Leapfrogged” Areas

Allegation/Basis

Sprawl fosters efficient in-fill development. Sprawl permits appropriate, relatively high-density development of still vacant close-in sites late in the development period of a metropolitan area, without having either to demolish existing improvements on those sites at great cost, or to expend public funds buying such sites in advance and reserving them for later development. The “leapfrogging” aspect of sprawl leaves sizable tracts of land vacant and undeveloped. Parcels remain vacant long after the wave of current growth has passed them by. These parcels can be developed later as “in-fill” sites at relatively high densities, which are more appropriate to their more central locations. This process of deferred development is more efficient than first developing all peripheral land at low densities, and then tearing down the existing structures when the development market, reflecting the preferences of structure occupants, shifts to higher densities.

Literature Synthesis

This allegation is considered by Peiser (1984) and is also discussed by Altshuler and Gomez-Ibanez (1993). But it is often a highly neglected component of the analysis of infrastructure costs related to sprawl. Just as there are those who call for full costing methods to expand and account for the costs of sprawl to the private sector and to society as a whole, there are, also those who believe that the secondary benefits of sprawl (i.e., its lagged in-fill economies) must be adequately tabulated in any accounting scheme related to development alternatives.

In an accounting system, the land areas that are skipped over and initially not used, become relatively inexpensive to access and service secondarily. Further, the potential for using these skipped-over lands as inner-ring open space also becomes apparent. Only Altshuler and Gomez-Ibanez (1993) have begun to address these issues.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?			X	
Is it strongly linked to sprawl?			X	

3.4 TRANSPORTATION AND TRAVEL COSTS

II.A. Sprawl's Alleged Negative Impacts

II.A.1. More Vehicle Miles Traveled (VMT)

Allegation/Basis

Sprawl generates more total miles of vehicle travel than more compact forms of development. Sprawl generates more travel because the places where people live, work, shop, and play are spread over a larger total area. Vehicle miles of travel also increase because sprawl developments are designed so that virtually the only way to make most trips is by automobile.

Literature Synthesis

There is no question that vehicle miles of travel are increasing. Vincent et al. (1994) found that on an annual basis, person miles of travel increased by 19 percent between 1983 and 1990 and vehicle miles of travel (VMT) increased at the even faster rate of 37 percent. Ray et al. (1994) found that the number and length of vehicle trips were increasing at an accelerating rate between 1977 and 1990.

The question is what proportion of the growth in VMT is due to sprawl versus other factors, such as a higher rate of women participating in the workforce, the baby boom generation being at the peak driving years, or rising incomes that allow every licensed driver in a household to own a car. Three factors have contributed about equally to the growth in VMT—changing demographics, growing dependence on the automobile, and longer travel distances (Dunphy et al. 1997). Thus, sprawl, which creates the longer travel distances and increases dependence on the automobile, is a major source of increased vehicle use.

Sprawl, which creates the longer travel distances and increases dependence on the automobile, is a major source of increased vehicle use.

Numerous studies have linked lower vehicle miles of travel with more compact mixed-use developments. In a 1990 analysis of the San Francisco Bay area and a 1994 study of 28 California communities, Holtzclaw found that residents of the denser neighborhoods drove fewer miles per year. In a second study, where Holtzclaw (1994) controlled for the levels of transit service and vehicle ownership, a doubling of residential densities was associated with 16 percent fewer vehicle miles of travel. Other research by Harvey (1990), 1000 Friends of Oregon (1996), and the Urban Land Institute (Dunphy et al. 1997) confirm that as densities increase, per capita vehicle miles of travel decline.

The interspersing of residents, employment, shopping, and other functions can also reduce VMT, by allowing shorter trips and the use of non-vehicle modes. An empirical analysis by Frank and Pivo (1994) in the Puget Sound region and a simulation of the Trenton region undertaken by the Middlesex, Somerset, Mercer Regional Planning Board (1990) in central New Jersey show that greater land use mixes (with a higher jobs-housing balance) decrease trip distances and automobile mode shares.

The segregation of uses and a leapfrog development pattern were both linked to increased travel in a recent Cervero (1996b) study of dispersed subcenters in the San Francisco Bay area. Between 1980 and 1990, the workers at these subcenters experienced a 23 percent increase in average commuting VMT. Cervero attributes 80 percent of the increase to longer distances between home and work.

Simulations of alternate growth patterns have also shown that sprawl development produces more VMT than more compact development. A simulation by Metro (1994) of growth in the Portland, Oregon metropolitan area compared a "Growing Out" scenario with new development continuing at current types and densities with a "Growing Up" scenario that kept all growth within the existing urban growth boundary by reducing lot sizes and introducing more multifamily housing. Average daily VMT was estimated to be 15 percent higher in the "Growing Out" scenario than in "Growing Up."

Gordon and Richardson (1997), however, do not agree that VMT would be reduced by more compact development. They contend that market forces embodied in sprawl may ultimately result in *less* VMT as households and businesses locate near one another. They further argue, based on Crane's (1996) theoretical analysis of travel on the grid street networks of neo-traditional development, that this neo-traditional, or compact, type of development may produce more VMT due to the ease of automobile travel. But Ewing (1997) points out that the demand for activities is relatively inelastic and residents of more compact, neo-traditional developments are unlikely to drive more simply because of better street design. A preponderance of evidence contradicts Gordon and Richardson's claim that sprawl is not a factor contributing to increased VMT.

Literature Synthesis Matrix

	+2 *General Agreement*	+1 *Some Agreement*	0 *No Clear Outcome*	–2 *Substantial Disagreement*
Does this condition notably exist?	X			
Is it strongly linked to sprawl?	X			

II.A.2. Longer Travel Times

Allegation/Basis

Sprawl requires that more time be spent traveling than do more compact forms of development. The greater dispersion of activities in sprawl makes it necessary to spend more time traveling between activities than in more compact, mixed use areas where trips are shorter and can serve multiple purposes. Workers in mixed use settings can eat lunch or run errands at noon without using significant amounts of time for travel. Residents of compact neighborhoods can meet many of their needs at community shopping centers.

Literature Synthesis

The evidence is mixed on the effects of sprawl on total travel times. Ewing (1995c) has shown that total travel time varies with regional accessibility. His Florida study found that residents of areas with high levels of access to a mix of uses including jobs, schools, shopping, and other services spent up to 40 minutes less per day in vehicular travel than residents in less accessible neighborhoods. Time was saved by linking trips into tours and by making shorter trips. Dunphy et al. (1997), on the other hand, also report that according to surveys, people are willing to accept longer travel times to work and shopping in order to have the quality of housing they desire. Thus, the segregation of land uses and less expensive land at the periphery, two characteristics of sprawl, can increase travel times; whereas mixed-use developments, wherever they are located, appear to decrease travel times.

Others contend that travel times do not increase with sprawl because more trips are made by the automobile, the fastest mode of travel, and people and activities adjust over time to keep travel times relatively constant (Gordon and Richardson 1997). A study by the European Conference of Ministers of Transport (1994) found that people in four cities with very different urban structures

Residents of areas with high levels of access to a mix of uses including jobs, schools, shopping, and other services spent 40 minutes less per day in vehicular travel than residents of the least accessible neighborhoods.

Wismar, West Germany; Delft, The Netherlands; Zurich, Switzerland; and Perth, Australia made about the same number of trips and spent about the same amount of time traveling even though modal shares differed significantly. The average time spent traveling ranged only from 62 to 69 minutes.

Purvis (1994) reported that travel time budgets remained fairly constant in the San Francisco Bay Area between 1960 and 1990. In the latest survey, the number of trips per person declined, but travel times remained constant because of the longer duration of trips. Purvis says the results are comparable to those in other metropolitan areas and consistent with the travel time budget studies of the 1970s and 1980s.

Overall, the evidence is not clear about the relationship between sprawl and households' total travel times. On the one hand, some metropolitan-wide data suggest that people have fairly constant travel time budgets. On the other hand, a finer level of analysis indicates that the outward expansion of urban areas and the segregation of uses has boosted the amount of time some households spend traveling to their daily activities.
(See also Shorter Commuting Times, under the positive impacts section, for a discussion of the mixed evidence on work trip duration under sprawl.)

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?			X	
Is it strongly linked to sprawl?			X	

II.A.3. More Automobile Trips

Allegation/Basis

A greater share of trips are made by car and a lesser share by transit, walking, and bicycling in sprawled development than in more compact development. This assertion is almost true by definition since one of the defining characteristics of sprawl is that motor vehicles are the dominant mode of transportation. Sprawl, with its low densities and spatial segregation of uses requires that virtually all trips be made by automobile, while residents of areas with higher densities and a greater mix of uses have the option of riding transit, biking, or walking.

Literature Synthesis

An extensive literature shows that when development is more compact and land uses are mixed, transit and walking mode shares rise and vehicle mode shares decline. Research for TCRP H-1 (Parsons Brinckerhoff 1996c) shows that residents of denser, more mixed-used neighborhoods were more likely to go by transit or walk for all types of trips. Another part of this project showed that higher residential densities in rail corridors and higher employment densities in the CBDs increase rail use (Parsons Brinckerhoff 1996b).

Empirical research by Cervero (1986, 1989), Dunphy and Fisher (1994), Frank and Pivo (1994), Kenworthy and Newman (1993), Cervero and Gorham (1995), Handy (1992, 1995), and Kitamura et al. (1994) confirm that higher density, more pedestrian-friendly neighborhoods and employment centers support travel by non-automotive modes. Kenworthy and Newman compared the rates of growth in central, inner, and outer neighborhoods in the United States (where those with higher incomes move to the edge) and Australia (where those with lower incomes move to the edge) and found that automobile travel was growing rapidly in the outer areas of cities in both counties. Their conclusion:

> It is clear that the level of automobile use is not simply a matter of how wealthy people are, but is also heavily dependent on the structure of the city and whether transport options are available other than the automobile. Thus as cities become more dispersed and lower in density towards the edges, the level of compulsory automobile use rises markedly, regardless of income level. (Kenworthy and Newman 1993.)

Even Gordon and Richardson (1997, p. 99) agree that "...the spreading out of cities reduces markets for conventional public transit (especially fixed rail, which is spatially inflexible and usually oriented to downtown)..."

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?	X			
Is it strongly linked to sprawl?	X			

II.A.4. Higher Household Transportation Spending

Allegation/Basis

Households living in sprawl developments must spend higher fractions of their incomes for transportation. Households under sprawl spend more for transportation than those in higher density forms of development because the residents of sprawl areas travel greater distances and make more of their trips in automobiles.

Literature Synthesis

That household spending on transportation is higher under sprawl would appear to be a logical consequence of the greater miles of travel and more travel by the automobile. However, only a few studies directly address the issue of household costs for transportation under different development scenarios.

Residents of denser, more transit-friendly neighborhoods are able to spend a smaller share of their budgets on travel due to greater use of transit and walking.

Holtzclaw (1994) concludes that residents of denser, more transit-friendly neighborhoods are able to spend a smaller share of their budgets on travel due to greater use of transit and walking. The impact is especially great if households can reduce their automobile ownership levels because of the viability of other modes of travel. However, it is unclear whether the lower transportation costs are a direct or indirect result of sprawl, due to the types of people who chose to live in the denser, more transit-friendly neighborhoods.

The current literature suggests that sprawl has higher transportation costs, but more studies are needed to substantiate this conclusion.

Literature Synthesis Matrix

	+2 *General Agreement*	+1 *Some Agreement*	0 *No Clear Outcome*	–2 *Substantial Disagreement*
Does this condition notably exist?			X	
Is it strongly linked to sprawl?			X	

II.A.5. Less Cost-Efficient and Effective Transit

Allegation/Basis

Sprawl reduces the cost-efficiency and effectiveness of transit service compared to more compact development. Transit service is not as efficient or effective in sprawl development because of the dispersion of origins and destinations. The higher ridership generated by denser developments improves the cost-efficiency (cost per vehicle mile) and effectiveness (passenger-miles per line-mile) of transit.

Literature Synthesis

Research for TCRP H-1 has shown that the use of light rail and commuter rail increases when more people live in the rail corridor and work in the central business district. Because density boosts ridership, the cost per vehicle mile declines and the passenger-miles per line-mile of transit increase. For example, consider a ten-mile light rail line serving a corridor with a medium residential density gradient and 100,000 employees in the CBD. If the residential density gradient were to increase by 1 to 4 persons per acre throughout the length of the line, the cost per vehicle mile would decline by about 5 percent and the effectiveness would increase by about 26 percent. Adding 50,000 jobs to the CBD and increasing employment densities would lower costs per vehicle mile by about 9 percent and increase effectiveness by 44 percent (Parsons Brinckerhoff 1996b, 1996d).

Transit service is not as efficient or effective in sprawl development because of the dispersion of origins and destinations.

As the section in this report on More Automobile Trips also shows, higher densities support higher bus use. Pushkarev and Zupan (1977) and a number of other authors have identified thresholds at which transit use substantially increases. Frank and Pivo (1994), using data from the Puget Sound region, identify thresholds of 50 to 70 employees and 9 to 13 persons per gross acre for work trips and 75 employees and 18 persons per gross acre for shopping trips.

Due to the increase in ridership at these densities, the cost-efficiency and effectiveness of transit service increases.

Of course, development patterns are not the only factor affecting the efficiency and effectiveness of transit. The level of transit use is also related to the quality of the transit service and the ease of access (i.e., walking environment, park-and-ride facilities). Costs are also related to wages and other aspects of transit operations.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?	X			
Is it strongly linked to sprawl?		X		

II.A.6. Higher Social Costs of Travel

Allegation/Basis

Travel in sprawl development generates higher social costs than in more compact development. Social costs include air and water pollution, waste, barrier effects, noise, and the costs of parking and accidents that are not paid by the transportation user. Because more travel is by automobile in sprawled development, these cost go up.

Literature Synthesis

Various studies of the full costs of travel have found that social costs are highest per passenger mile for single-occupant vehicles, the dominant mode of travel under sprawl conditions. Studies using similar methods and location specific data for Boulder, Colorado, Boston, Massachusetts, and Portland, Maine report that 16 to 17 percent of the costs per passenger mile for single occupant vehicles (SOV) are social costs while only 1 to 7 percent of the total costs for transit use and a negligible share of the costs for walking and bicycling are social costs (Apogee Research 1994; Parsons Brinckerhoff 1996a). Todd Litman’s (1995) study estimating the national costs of travel reports that social costs represent a higher share of total costs due to different assumptions. He finds that 43 percent of the cost per passenger mile by SOV is societal costs compared to 6 percent of the cost per passenger mile by transit.

Various studies of the full cost of travel have found that social costs are highest per passenger mile for the single occupant vehicle, the dominant mode of travel under sprawl conditions.

Previous studies examined the social costs of travel from both a trip and a national perspective. The issue of whether the total costs of travel vary with the type of development, however, has not been studied systematically and is one of the hypotheses to be evaluated in the TCRP H-10 study.

Literature Synthesis Matrix

	+2 *General Agreement*	+1 *Some Agreement*	0 *No Clear Outcome*	–2 *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?		X		

II.B. Sprawl's Alleged Positive Impacts

II.B.1. Shorter Commuting Times

Allegation/Basis

Commuting times are reduced in sprawl development, compared to those in more dense settings. The suburban-to-suburban commute, which characterizes sprawl, is shorter in time, if not in distance, than commuter trips between suburbs and central cities, due to higher speeds of travel. In addition, more trips are made by automobile, especially the single-occupant vehicle, the fastest and most direct mode of travel.

Literature Synthesis

Gordon and Richardson (1997) argue that businesses follow people to the suburbs, thereby making trips to work shorter, as measured in time, not in distance. The correction is not instantaneous, but over time, businesses move to suburban locations near workers, creating a new equilibrium with shorter work times. Although some people have longer trips, especially during the adjustment period, on average, commuting times have not increased due to sprawl.

Pisarski (1992) found that average work trip times in the U.S. increased by only 40 seconds in the 1980s. Gordon, Richardson, and Jun (1991) and Levinson and Kumar (1994) found that work travel times remained stable over time in the core counties of the 20 largest metropolitan areas and in the Washington, DC metropolitan area, respectively. Dueker et al. (1983), Zimmer (1985), Gordon, Kumar, and Richardson (1989), and Dubin (1991) all found that the suburbanization of jobs has shortened commuting times, although not necessarily distances.

The suburbanization of jobs has shortened commuting times, although not necessarily distances.

But, there is contrary evidence. Vincent et al. (1994) analyzed the National Personal Transportation Survey Data for 1990 and found that commute times for residents of urbanized areas outside of central cities were longer than those for central city residents. The average peak period commute length for suburbanites was 21.6 minutes, compared to 18.9 minutes for central city residents. Likewise, the average length of off-peak commutes for suburbanites was 19.7 minutes compared to 17.2 minutes for central city residents. Pisarski (1996) further reports that suburbanites had much greater increases in commute times between 1980 and 1990 than central city residents. The average travel time for suburban residents who commuted either to suburban or central city locations increased by 14 percent over the period, while the average commute time for a central city resident increased by only 5 to 7 percent.

The extreme outward expansion of urban areas may have also increased travel times. Davis (1993) found that the average commute of exurbanites in the Portland metropolitan area was seven minutes longer than that of suburbanites, holding constant occupations, household structure, and other factors affecting commuting times.

Commute times for residents of urbanized areas outside of central cities were longer than those of central city residents.

Thus, researchers have drawn substantially different conclusions, sometimes utilizing the same data sets. Most of their studies addressed issues other than the effects of sprawl versus compact development on commuting time, however, leaving the results unclear.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?			X	
Is it strongly linked to sprawl?			X	

II.B.2. Less Congestion

Allegation/Basis

Sprawl reduces congestion by spreading trips out over more routes. Sprawl has improved travel by spreading out origins and destinations and utilizing the capacity of suburban roads and highways. The shift to suburban destinations has relieved traffic on the routes to the city center.

Literature Synthesis

Gordon and Richardson (1996c) claim that suburbanization has reduced congestion, citing the lack of growth in travel times. Specifically, they say:

> ...suburbanization has been the dominant and successful mechanism for reducing congestion. It has shifted road and highway demand to less congested routes and away from core areas. All of the available recent data from national surveys on self-reported trip lengths and/or durations corroborate this view. (Gordon and Richardson 1996c, 1)

They argue that, over time, people and firms make adjustments in their locations to keep travel times from growing. The spreading out of urban areas has kept congestion from overwhelming urban areas as some have predicted.

Congestion got worse in 47 out of 50 major cities between 1982 and 1991.

Cervero (1986, 1989), however, found that congestion has followed jobs to the suburbs. Since jobs have moved to areas where there is little, if any, transit service, people have no choice but to drive to these jobs. This increase in traffic has used up all the available highway capacity near suburban activity centers, creating congestion in these areas. An index developed by the Texas Transportation Institute indicates that congestion (defined as the ratio of freeway and arterial VMT to capacity) got worse in 47 out of 50 major U.S. cities between 1982 and 1991. Two of the cities where congestion decreased, Houston and Phoenix, made sizable investments in highway capacity during the time period. This research points to a factor other than development pattern which contributes to congestion, namely, investment in transportation. In most areas, highway capacity additions have not kept pace with the growth in traffic, due to lack of funds, opposition to road building, environmental regulations, and other factors (Dunphy et al. 1997).

Simulations also show that in addition to the pattern of development, roadway networks and capacity, congestion levels depend upon the opportunities to use alternative transportation modes. The LUTRAQ analysis of alternate development patterns for a suburban county in the Portland, Oregon metropolitan area, for example, forecast the least congestion for a pattern of sprawled development with substantial investments in additional highway capacity and transportation demand reduction measures, such as pricing. Compact transit-oriented development focused on an expanded transit system, using the same transportation demand measures, had the second lowest levels of congestion. Building highways in sprawl development without controlling travel demand had higher levels of congestion than either of these two alternatives (1000 Friends of Oregon 1996).

Because researchers disagree about how to measure congestion, they also disagree about whether congestion is getting better or worse. Regardless, both sides agree that suburbanization is one of the major factors affecting congestion levels.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?			X	
Is it strongly linked to sprawl?	X			

II.B.3. Lower Governmental Costs for Transportation

Allegation/Basis

Much of the cost of building and operating highways and streets, the dominant mode of travel under sprawl, is paid for by users, through gas taxes and licensing fees. In contrast, transit users pay a lower share of the costs of building and operating transit systems, especially rail systems. Thus sprawl, with its emphasis on highway investment, requires less subsidization of transportation systems even when governmental costs, such as highway patrols and publicly provided parking, are considered.

Literature Synthesis

Considerable disagreement exists about whether transit or automobile governmental subsidies are higher, as evidenced by the debate between Gordon and Richardson (1997) and Ewing (1997). Although government subsidies are a visible part of transit budgets, there is much dissension about what constitutes a subsidy for highways. As Delucchi notes:

> There is a good deal of argument about whether motor-vehicle users "pay" fully for government-provided infrastructure and services (i.e., Lee 1994: Green 1995). This disagreement, of course, results from different opinions about what should count as a public-sector cost of motor-vehicle use, and what should count as a payment by motor-vehicle users for motor-vehicle use. (Delucchi 1996, 43)

There is a good deal of argument about whether motor-vehicle users "pay" fully for government-provided infrastructure and services.

Most federal and state funding of highways come from the gas taxes and registration fees that are dedicated to highways. However, as Hanson (1992) Litman (1995), and Dunphy (1997) point out, local governments finance a considerable share of road costs with property and sales taxes.

None of the costs of travel studies have analyzed whether governmental costs vary depending upon the type of development. This issue is being addressed in the TCRP H-10 study.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?			X	
Is it strongly linked to sprawl?			X	

II.B.4. Automobiles Most Efficient Mode of Transportation

Allegation/Basis

Automobiles are an the most efficient mode of transportation in sprawl. The low density, dispersed patterns of sprawl development, were designed for automobile access, and make the automobile the most efficient means of travel for many trips.

Literature Synthesis

An analysis of the total cost of travel for ten diverse, prototypical trips in Boulder, Colorado showed that the automobile is clearly the *least* costly means of travel for trips between dispersed, low-density destinations even when estimates of user, governmental, and social costs are totaled. Although the cost per passenger mile of the single-occupant automobile is higher than the cost of any other mode during peak times, automobiles are more efficient for many off-peak trips because they can take direct routes, are faster, and allow drivers to avoid waiting times. Getting to destinations that require bus transfers; taking trips that link many destinations; or taking trips involving more than one person are often most efficiently done in the automobile.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?	X			

3.5 LAND/NATURAL HABITAT PRESERVATION

III.A. Sprawl's Alleged Negative Impacts

III.A.1. Loss of Agricultural Land

Allegation/Basis

Sprawl removes more prime agricultural land from farming use than other more compact forms of development.

Literature Synthesis

Multiple studies have documented the significant loss of agricultural lands to the current development process. These studies range from national reviews of the loss of farmlands and farms over time, such as the National Agricultural Lands study (1981) and the American Farmland

Trust's *Farming on the Edge* (1994), to regional/state investigations of a similar type (i.e., Nelson [1992] in Oregon and Adelaga [1991] in New Jersey). There is substantial disagreement, however, about whether this loss of agricultural land has created significant social costs. To some observers, it appears that there is no shortage of prime agricultural land in the United States, since the nation has often produced crop surpluses (Gordon and Richardson 1997), and 2,000 of the 3,000 counties in the U.S. can still be counted as rural and undeveloped (Burchell and Shad 1997). Yet, demands for food are rising sharply, as living standards increase in once-poor locations throughout the world. Prices of major agricultural crops have increased substantially in just the last few years. Hence, the argument is made that in the long run, the world will need all the food production capacity it can muster (Ewing 1997).

What limited empirical investigations of sprawl's impact on "consuming" farmland—and in opposition, the impact of alternatives to sprawl on farmland—that have been done were performed by Burchell et al. (1992-1997) in New Jersey, Lexington, Kentucky, the Delaware Estuary, Michigan, and South Carolina, and by Landis (1995) in the San Francisco Bay area. These analyses employed land consumption models at the minor civil subdivision level to view differences between trend development or "business as usual" scenarios and more environmentally conscious land development approaches. The business-as-usual scenarios embodied sprawl-like characteristics; the latter, more compact, planned development characteristics. These models allowed future projections of households and jobs to be converted to the demand for residential and nonresidential structures, and ultimately to demand for residential and nonresidential land, with allowances for spill over to adjacent municipalities and to unincorporated areas.

Numerous growth management plans include farmland preservation as an objective.

In both the Burchell and Landis studies, historical rates of farmland takings were applied to land consumed under existing development patterns, and the goal of farmland retention was applied under the alternative development patterns. (A similar procedure was used for environmental land consumption comparisons.) In the Burchell study, agricultural lands included such categories as cropland that is harvested, lands in permanent pasture, and woodlands that could be used for agricultural purposes. Fragile environmental lands encompassed floodplains and wetlands, acreage with steep slopes or with critical habitat designation, aquifer recharge areas, and critical sensitive watersheds, and stream buffers (Burchell et al. 1992-1997).

The models, employing different densities, development locations, and occasionally different housing types under the alternatives for future growth, calculated the total agricultural (and fragile environmental lands) that would be consumed. Burchell's results showed savings in the consumption of agricultural acreage of roughly 20 percent in South Carolina, Michigan, and Lexington under plan versus trend development; savings of about 30 percent in the Delaware Estuary; and savings of 40 percent in New Jersey (Burchell et al. 1992-1997). (See Tables 3 and 4 for details). Landis's results in the San Francisco Bay Area were even more pronounced. His "scenario C" (compact growth) saved nearly 50% of farmland acreage and steep sloped areas, and close to 100% of wetland areas (Landis 1995, 449).

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?	X			
Is it strongly linked to sprawl?	X			

II.A.2. Reduced Farmland Productivity

Allegation/Basis

The productivity of land being farmed near scattered sprawl settlements is reduced by the difficulty of conducting efficient farming operations near residential subdivisions.

Literature Synthesis

There is an extensive literature on constraints to farming in urbanizing locations (Lisansky 1986; Lopez et al. 1988; and Nelson 1992). In rural areas that can be readily developed, high land values often shift farmers' "objective function" from agricultural operations to capital gains from real estate sales. Real estate sales, in turn, reduce the average farm size, thus limiting the realization of economies of scale—a characteristic of U.S. agriculture. A variety of other restraints on farmland productivity have also been imposed, ranging from restrictive regulations to recurring vandalism. All of these factors generate an "impermanence syndrome"—a reluctance by the farmer to invest in new technology and farm infrastructure. Land remains idle, awaiting conversion to other uses. Studies involving sprawl development allege that this impermanence syndrome is deleterious to farmland productivity (AFT 1997).

The direct relationship of sprawl development patterns to farmland consumption was examined by Burchell et al. (1992a) in the state of New Jersey. In addition to projecting the total farmland that would be lost under sprawl versus planned development, the New Jersey analysis identified the quality of farmland that would likely be consumed—"prime," "marginal" or "poor." The New Jersey analysis showed that not only would continued sprawl development draw down more farmland, but since better quality farmland is the most amenable for development (in that it is flatter, drains better, and so on) the loss of farmland to sprawl would be concentrated in the "prime" and "marginal" categories. Farmland consumption under planned development would be less overall, and wholly contained in the subprime or "poor" farmland category.

No analysis to date has examined how development pattern (i.e., sprawl versus compact) would affect the productivity of farmland that remains in agricultural use.

The Burchell et al. (1992a) New Jersey study thus considered the association of farmland quality and development patterns—but only from a farmland consumption perspective. No analysis to date has examined how development pattern (i.e., sprawl versus compact) would affect the productivity of farmland that remains in agricultural use.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

III.A.3. Reduced Farmland Viability (Water Constraints)

Allegation/Basis

Growth through sprawl causes great expansion in the demand for water for urban uses, and thereby reduces the amount of water available for agriculture.

Literature Synthesis

Multiple studies have examined how development in more arid locations, especially in the West and Southwest United States, is drawing down the water supply, potentially in conflict with the irrigation needs of agriculture. The literature has not examined the specific association of sprawl and farmland viability with respect to water supply. This would involve a multi-linked analysis of:

1) How development affects water demand;
2) Whether development's consumption of water would differ under sprawl versus other forms of development in these areas; and
3) The relationship of steps (1) and (2) to the amount of water supply for agricultural and residential settlements in given locations, compared to the total supply available there.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?			X	
Is it strongly linked to sprawl?			X	

III.A.4. Loss of Fragile Environmental Lands

Allegation/Basis

More frail lands are destroyed by sprawl than by more compact settlement patterns.

Literature Synthesis

Several studies document losses of and threats to fragile lands. Dahl (1990) estimates that since colonial times the United States (48 lower states) has lost about 110 million acres of wetlands—about 55 percent of the starting wetlands inventory. The Michigan Society of Planning Officials (MSPO) estimates that 20 percent of Michigan's forested, wetland, and steeply sloped areas were lost to development between 1970 to 1990 (MSPO 1990).

Numerous growth management plans—attempting to reverse sprawl—have evaluated how managed versus traditional development patterns would affect fragile lands. These plans include the Orlando, Florida *Urban Area Growth Management Program* (Orlando FL 1981), the *Evaluation of City of San Diego Growth Management Program*, and *the Report of the Year 2020 Panel of Experts (*Chesapeake Bay Executive Council 1988). The Orlando study examined how managed growth versus a "continuation of past trends" would affect the preservation of wetlands and flood plains. It projected a saving under managed growth of almost 20 percent in the inventory of these fragile environmental lands, (i.e., 20 percent less acreage lost).

The Michigan Society of Planning Officials (MSPO) estimates that 20 percent of Michigan's forested, wetland, and steeply sloped areas were lost to development between 1970 to 1990.

Analyses of sprawl's impact on fragile lands have been conducted by Burchell et al. (1992–1997) in New Jersey, Lexington, Kentucky, Delaware Estuary, and Michigan. Similar studies were also done by Landis in the San Francisco Bay area. Burchell et al. found that plan (compact) versus trend (sprawl-like) development would reduce consumption of fragile environmental lands by almost one-fifth.

The range of the saving was from 12 to 27 percent, depending on the starting level and location (see Tables 3 and 4). Landis found even larger land savings under his compact growth scenario. His findings were calculated separately for steep slopes and wetland areas (Landis 1995).

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?	X			
Is it strongly linked to sprawl?	X			

III.A.5. Reduced Regional Open Space

Allegation/Basis

The setting aside of open space for public use by residents of an entire region may be "underfinanced" in sprawl-dominated areas, compared to those with more regionally oriented governance structures.

Literature Synthesis

There is scant literature dealing with this issue explicitly; it is difficult to determine whether a substantial consensus exists. The only literature that does exist finds that very large scale developments and conservation developments, both generally "non-sprawl" in nature, frequently have significant set-asides for contiguous open space. Most of the local ordinances of the 1970s and the new countywide community general development plans of the 1980s called for mandatory provisions of continuous open space as an alternative to traditional subdivision development (Burchell, Listokin, and Dolphin 1993).

Very large scale developments and conservation developments, both often of a non-sprawl nature, frequently have significant set-asides for contiguous open space.

Arendt (1994) points to a movement away from golf course communities to open space communities that give the private and public sectors a greater chance to share in the land resources. The Sterling Forest Corporation, potential developers of a 17,500-acre site in Tuxedo, New York, pledged 75% of the land would remain as some form of private/public open space (Sterling Forest Corporation 1993). Much of the site was later bought by federal and state governments.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?			X	
Is it strongly linked to sprawl?			X	

III.B. Sprawl's Alleged Positive Impacts

III.B.1. Enhanced Personal and Public Open Space

Allegation/Basis

(a) *Sprawl provides more open space directly accessible to individual households in the form of larger private yards attached to their dwellings than is possible via more compact forms of settlement.*

(b) *Sprawl's leapfrog development provides both larger amounts of and more accessible open space without significant public expenditures, by leaving large unsettled sites "inboard" of the farthest-out urban subdivisions.*

Literature Synthesis

Personal open space continues to be high on the list of the desires of most Americans (Fannie Mae 1995). In surveys conducted by the Federal National Mortgage Agency, prospective home buyers want not only yards, but yards on all sides. In the mid-1990s, according to the most current surveys of buying preference, single-family detached housing was more popular than it was a decade ago. Much of the appeal is related to occupants' dislike of the instability or fee structure of condominium associations. But at least some of the appeal is related to the desire for more, rather than less, personal open space (Fannie Mae 1995).

A very limited literature indicates that the skipped-over development patterns of sprawl create parcels of land that can be used for inner-suburban or urban open space as this becomes a local priority. Except in the wealthiest and most resilient of inner suburbs, open space is almost never a choice or option of local government. Most governments in these localities feel pressed for fiscal resources and dispose of these land parcels to the highest bidder. Thus, the opposite to what is popularly assumed to be a trend often takes place. Through the local variance process, the lands frequently are given a higher intensity residential or nonresidential use designation.

Although there appears potential for inner open space to be the result of skipped-over lands, rarely does this happen in either developed or redeveloping neighborhoods.

The abutting properties, rather than receive permanently improved open space, are subject to more intensive and occasionally disruptive land uses, which can pay more in taxes than either existing neighboring use or the previously undeveloped vacant land. Thus, although a potential for inner open space appears to be the result of skipped-over lands, rarely does new open space materialize in either developed or redeveloping neighborhoods (Downs 1994).

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

3.6 QUALITY OF LIFE

IV.A. Sprawl's Alleged Negative Impacts

IV.A.1. Aesthetically Displeasing

Allegation/Basis

Low-density patterns are less pleasing aesthetically and provide fewer cultural opportunities than high-density patterns.

Literature Synthesis

The aesthetically less pleasing aspects of sprawl, such as visual uniformity, are often cited as a cost of this form of development (Nelessen 1994). Critics of sprawl often decry its ugliness. For example, Shore (1995) maintains that "spread city" is inherently ugly because the settlement pattern has no clear form; retail businesses located along highways must use "raucous" signs to attract passing motorists; and a significant portion of the land is given over to the automobile. James Kunstler in a public presentation in Lansing, Michigan in 1996 described U.S. suburbs as "useless and without purpose and occupied by people of the same make-up" (Kunstler 1996b).

Low-density developments, however, are not necessarily less pleasing aesthetically than more compact forms of development. The aesthetics vary from development to development. Some low-density residential developments, particularly high-income ones, have much more open space and elaborate landscape designs than high-density residential areas. In fact, defenders of sprawl often contend that the individually owned, discrete open spaces of sprawl make it more attractive than compact forms of development.

There is little evidence within the literature to suggest that Americans find sprawl less attractive than more compact forms of development.

The literature reflects these two conflicting opinions. There is little evidence within the literature, however, to suggest that Americans find sprawl less attractive than more compact forms of development or that low-density living provides them with fewer cultural opportunities. Visual preference surveys have been used to gauge the reaction of Americans to sprawl, although such studies are often criticized for failing to make a distinction between sprawl and factors not typically associated with that form of development, (e.g., architectural design). Moreover, survey research does not consistently indicate that Americans overwhelmingly find sprawl to be aesthetically less pleasing than compact forms of development. When shown images of both sprawl and traditional communities, some surveys have revealed that individuals favor the latter by a wide margin (Neuman 1991). But some aspects of sprawl appear to appeal to Americans. Individuals were found to favor homogeneous neighborhoods over mixed neighborhoods by a margin of two to one (Bookout 1992). Survey research in Florida has suggested that individuals there have a strong preference for low-density or exurban living (Audirac and Zifou 1989).

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

IV.A.2. Weakened Sense Of Community

Allegation/Basis

Low-density development weakens households' connections to both their immediate neighbors and to the larger metropolitan community, and encourages unsocial values.

Literature Synthesis

Critics of sprawl often claim that a loss of "sense of community" is one of its greatest social costs (Ewing 1997). Defenders of low-density settlements, however, deny that residents experience any less "sense of community" than residents in big cities or more compact settlements (Gordon and Richardson 1997). In fact, the evidence from as far back as 1954 (Herbert Gans as cited in Jacobs 1961) indicates that some dense areas lack community, while some suburban areas have it. Much of the controversy arises because "sense of community" is difficult to define and even more difficult to measure.

"Sense of community" is difficult to define and even more difficult to measure.

In his review of the literature on "sense of community," Cochrun (1994) finds that the term has been used to describe a number of disparate elements, but the most comprehensive definition was developed by McMillan and Chavis (1986). McMillan and Chavis identified four factors that contribute to a sense of community:

1) Membership;
2) Influence;
3) Integration and fulfillment of needs; and
4) Shared emotional connection.

Cochrun offers a definition of "sense of community" that incorporates the four factors identified by McMillan and Chavis:

> People who have a strong sense of community feel like they belong in their neighborhoods, they believe they exert some control over what happens in their neighborhoods while also feeling influenced by what happens in them, and they believe that their needs can be met through the collective capabilities of their neighborhoods. (Cochrun 1994, 93)

In *Edge City: Life on the New Frontier,* Garreau (1991) searches for a definition of community, particularly within edge cities, and reaches the conclusion that community and neighborhood no longer mean the same thing. Instead, Garreau maintains that "mobility" and "voluntary" are two important terms that help to define community—individuals want to be able to both join and leave communities at their choosing. Moreover, Garreau contends that a community should be a "social grouping" that is readily available to individuals and does not interfere with individual freedoms.

In partial contradiction, Lemann (1989), in an article examining changes in suburban Illinois, found that community building efforts in Naperville, a fast-growing suburb of Chicago, were hindered by the high rate of turnover of its residents.

Critics of sprawl argue that residents in mixed-used neighborhoods have more sense of community and social interaction than do residents living in low-density developments because they are more likely to walk from place to place and, consequently, they are more likely to have contact and interaction with others. Residents in low-density areas, on the other hand, rely more on their cars for shopping and recreation trips and, hence, are less likely to develop contacts and friendships with neighbors (Nasar and Julian 1995). Drawing on the work of Glynn (1981), Nasar and Julian assessed the psychological sense of community across different neighborhoods and housing conditions in northwest Columbus, Ohio. They found that residents of mixed-used areas had significantly more sense of community than residents of single-use neighborhoods.

Ewing suggests, however, that low-density development does not provide residents with any less "sense of community" than higher-density development. After reviewing extensive literature on sprawl, he concludes that there is not enough evidence to determine whether a lack of an identifiable community is associated with sprawl (Ewing 1994a).

One further issue related to a lack of "sense of community" is the emergence of a "throw-away" mentality or, more elegantly, the lack of value for ecology and sustainable life styles. Some argue that sprawl encourages the "throw-away" mentality among households.

Sprawl development may be seen as a continuation of the "prairie psychology" of early American settlers who believed they could change their current situation by leaving existing homes and problems behind and moving west onto vacant land.

In a sense, sprawl development may be seen as a continuation of the "prairie psychology" of early American settlers who believed they could change their situation by leaving existing homes and problems behind and moving west onto vacant land (Delafons 1962). More recently, millions of American households have moved out of central cities and older inner-ring suburbs for the same reason—to escape the problems of those areas. They have left the problems behind for others to solve. Few, if any, studies of sprawl have dealt with this issue, and none have proposed any way to measure the "throw-away" mindset.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

IV.A.3. Greater Stress

Allegation/Basis

Because people spend more time driving, they have less free time and more stress..

Literature Synthesis

Here, as with many of the topics evaluated in this report, there is substantial overlap with other topics and their alleged effects. In this case, the overlap is with transportation effects, which include allegations about traffic congestion and travel times.

Increased travel impedance, as measured by commuting distance and time, is associated with increased measures of stress.

There is evidence that greater commuting time increases the stress of commuters. Novaco et al. (1990) found that increased travel impedance, as measured by commuting distance and time, is associated with increased measures of stress. Travel impedance was also found to have statistically significant effects on job satisfaction, work absences due to illness, and overall incidence of colds or flu. Subjective or perceived conditions of travel impedance were found to have statistically significant effects on mood at home in the evening and chest pain. Consequently, the study found that job change, in its sample, was primarily related to commuting satisfaction. The study validated results from the author's previous work, which had found that impedance characteristics of commuting raise stress levels, as measured by effects on blood pressure, tolerance for frustration, negative mood, and overall life satisfaction. This earlier work also found that the desire to change residence because of transportation conditions was related strongly to high impedance (Novaco et al. 1979; Stokols and Novaco 1981; Stokols et al. 1978). The physical stress effects of impedance have also been corroborated by a study of the effects of average commuting speed on blood pressure and proofreading measures (Schaeffer et al. 1988).

Although the link between commuting and stress is well established, the literature on the stress effects of commuting does not rigorously address the link between commuting stress and the density of development or urban form. Novaco et. al. (1990) begin to address this link with their finding that stress effects are strongly associated with freeway travel and with road exchanges; they also assert that freeway travel in southern California has become increasingly congested because roadway capacity has not kept pace with continued growth.

Literature on the stress effects of commuting does not rigorously address the link between commuting stress and the density of development.

Although it has been alleged that commuting through the aesthetically unattractive commercial strip development typical of sprawl produces more psychological stress on commuters than does commuting through environments dominated by trees and open space, very little literature pertaining to this allegation exists. One study, however, claims to have tested commuters psychologically and arrived at a finding that supports this claim (Ulrich et al. 1991).

Other sections of this report comment in more detail on the evidence regarding sprawl and travel time. No conclusion is made here. The professional literature suggests, however, that commuting can be shown statistically to contribute to stress—a happy coincidence of science and common sense.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?		X		

IV.A.4. Higher Energy Consumption

Allegation/Basis

Under sprawl, society consumes more scarce energy, especially imported oil.

Literature Synthesis

Ewing (1997) and many other researchers, contend that the evidence consistently demonstrates that automobile use, and hence energy use, is higher with sprawl. Yet, Gordon and Richardson (1997) are not convinced that the link between vehicle miles of travel, energy use, and density is firmly established.

Coloring this argument are the differing perspectives on energy availability. Gordon and Richardson (1997) speak of an energy glut and an OPEC cartel that has lost its clout, while Ewing (1997) cautions that energy sources are not unlimited and reliance on foreign energy supplies is a continuing concern for United States foreign policy.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?			X	
Is it strongly linked to sprawl?			X	

IV.A.5. More Air Pollution

Allegation/Basis

Sprawl worsens the overall air pollution in a metropolitan area.

Literature Synthesis

Most, but far from all, observers agree that low-density settlements generate more total automotive travel than more compact settlements, other things being equal (see prior discussion). Therefore, low-density settlements are presumed to generate more auto-oriented emissions per 100,000 residents. However, the intensity of air pollution in each metropolitan area is affected by many factors, including the locations of major urban centers, prevailing winds, mountain barriers, temperature inversions, and general climate. Hence, there is disagreement as to the extent to which sprawl is a key factor in determining the degree of air pollution in each metropolitan area.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

IV.A.6. Lessened Historic Preservation

Allegation/Basis

Sprawl makes it difficult to preserve historically significant older structures.

Literature Synthesis

This allegation has been put forward mainly by the National Trust for Historic Preservation in its various publications attacking sprawl.

The following argument (Beaumont 1996) summarizes the reasoning behind the professed association between sprawl and preservation. Beaumont is one of the few observers of sprawl who has commented on whether or not this association is valid.

According to Beaumont, sprawl affects historic preservation in five major ways:

1) Sprawl adversely affects older downtown areas and neighborhoods, where historic buildings are concentrated. When the economic vitality of a historic area suffers, the buildings in it often become underused or empty. Over time, many of them are "demolished by neglect" or torn down to make way for surface parking lots.

2) Sprawl destroys community character and the countryside. Cohesive main streets, old stone fences, historic trees, country roads—these and other features of the American landscape are rapidly being destroyed by sprawl development and the vast expanses of asphalt required to accommodate it.

3) Sprawl reduces opportunities for face-to-face interaction among people, thereby making it more difficult to create, or retain, a sense of community. By scattering the elements of a community across the landscape in a haphazard way, sprawl provides no town centers and reduces the sense of ownership—and therefore also the commitment—that people have toward their community.

4) Sprawl forecloses alternatives to the automobile as a means of transport, thereby adding to pressures to create or widen roads that often result in the demolition of historic resources or the degradation of their settings.

5) Sprawl leaves older cities and towns with excessive ly high concentrations of poor people with social problems, making these places a very difficult environment in which to revitalize communities. (Beaumont 1996, 264)

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

IV.B. Alleged Positive Impacts

IV.B.1. Preference for Low-Density Living

Allegation/Basis

Many households prefer low-density residential living.

Literature Synthesis

The fact that so many Americans choose to live in low-density areas has been cited as strong evidence that Americans prefer that lifestyle. The most recent annual survey by Fannie Mae (1996) shows that home ownership is a top priority for 69 percent of Americans, and 73 percent desire a single-family detached house with a yard on all sides.

A study that generated quality-of-life rankings for the fifty U.S. states over the period 1981–1990 found that sparsely populated, mountainous Western states such as Montana and Wyoming had a higher quality-of-life ranking than the more densely populated Midwestern and Eastern states (Gabriel et al. 1996). Urban congestion has been cited by “lone eagles” (individuals who are able to live anywhere and telecommute to work) as a factor influencing their decision to move (Salant et al. 1996).

A 1997 issue of the *Journal of the American Planning Association* (Winter 1997) has two articles dealing with sprawl that summarize many of these arguments. Gordon and Richardson (1997) revisit several issues relevant to the compact cities discussion, including residential density preferences. They maintain that consumers, given the choice between low-density suburban living and high-density urban living, overwhelmingly choose the former: “But that suburbanization itself should be an object of attack is amazing, given the expressed preferences of the majority of Americans for suburban lifestyles and the supposed sanctity of consumer sovereignty” (p. 99). Drawing on the literature, they attempt to dispel the belief that the choice of low-density residential living is a constrained choice, strongly influenced by government policies that promote suburbanization, including subsidized automobile use and zoning laws that restrict high-density development.

Though Ewing (1997) agrees with Gordon and Richardson (1997) that the recent choice of U.S. households has been for low-density suburban living over high-density urban living, he contends that given a larger set of single family residential environments, consumers do not necessarily favor the former: “There is strong consumer preference for new single-family detached housing—a housing type concentrated in the suburbs. But most people could do without the rest of the suburban package” (Ewing 1997, 111). Ewing maintains that compact development is capable of holding its own in the marketplace, and cites evidence from the literature on consumer preferences. According to Ewing, the literature reveals several interesting facts:

1) The suburbs often rank below small towns, villages, and rural settings as a desirable place to live
2) Home buyers, given a choice, are evenly divided on whether they prefer low- or medium-density residential settings
3) Home buyers in high-priced housing markets often prefer small-lot houses
4) The public, given a choice, is almost evenly divided on whether it prefers mixed- or single-use areas. (Ewing 1997, 111)

In his earlier study, “Characteristics, Causes, and Effects of Sprawl: A Literature Review,” Ewing (1994) offered additional evidence to bolster his contention that consumer preference surveys do not clearly support low-density living over more compact forms of settlement. Surveys where people are shown images of both sprawl and traditional communities reveal that, for the most part, the latter are favored by wide margins (Neuman 1991). Some surveys, however, have found that people favor homogeneous neighborhoods over mixed-use neighborhoods by a margin of about two to one (Bookout 1992), and that people prefer low-density suburban or exurban living (Audirac and Zifou 1989).

Recent choice of U.S. households has been for low-density suburban living over high-density urban living.

Other surveys of consumer preferences have also shown mixed results. A September 1995 survey of people who shopped and ultimately bought units in planned communities indicated that 57 percent of the respondents agreed with the statement "I'm tired of living in the sterile uniformity of most suburbs." Yet, more than three-fourths of the respondents believed in the American dream of a big yard and a house set back from the street (Bradford 1996).

57 percent of the respondents agreed with the statement "I'm tired of living in the sterile uniformity of most suburbs." Yet, more than three-fourths of the respondents believed in the American dream of a big yard and a house set back from the street.

There may be something approaching universal agreement that U.S. residential patterns in metropolitan areas have become increasingly suburbanized (i.e., have lower density or sprawl). There is probably close to general agreement that many, if not a majority, of U.S. households prefer single-family detached housing given current options and prices—albeit observers raise the issue whether households would move in significant numbers if other options were available.

The question about whether sprawl is strongly linked to these residential choices is a matter of interpretation. At one extreme, the choice of low-density housing is, in essence, the definition of sprawl, so the question of whether it is caused by sprawl is a circular one. Another interpretation is that the mere existence of the pattern (sprawl) and its accompanying low-density housing influences people's preferences, like the advertising of any product.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?	X			
Is it strongly linked to sprawl?		X		

IV.B.2. Lower Crime Rates

Allegation/Basis

Low-density development patterns have lower crime rates.

Literature Synthesis

Statistics appear to indicate that urban residents experience higher rates of crime than their suburban or rural counterparts. In 1994, the estimated rate (per 1,000 persons aged 12 and older) of personal victimization which includes robbery, assault, rape, and personal theft—was highest for inhabitants of urban areas (67.6). Suburban areas experienced a rate of personal victimization of 51.8; rural areas had a rate of 39.8 (Pastore and Maguire 1996). 1995 crime statistics released by the Federal Bureau of Investigation (FBI) indicate that the Crime Index (comprised of selected violent and property offenses) was higher in Metropolitan Statistical Areas (MSAs) (5,761 per 100,000 inhabitants) than cities outside MSAs (5,315 per 100,000). Rural counties had the lowest index number of 2,083 per 100,000 inhabitants (Federal Bureau of Investigation 1996).

Other research, however, does not strongly indicate that the higher-density living commonly found in urban areas is associated with higher crime rates. Using 1974 census data, Newman and Kenworthy (1989a) correlate density with crime statistics for 26 major U.S. cities. Simple linear correlations suggest that there is no significant relationship between crime and density. Similarly, correlational studies within the environmental psychology literature find no consistent relationship between population density and social pathologies (Sherrod and Cohen 1979).

Several studies indicate that communities with high quality-of-life rankings exhibit low crime rates (Roback 1982, 1988). The amount of crime in a community may also affect migration patterns for both workers and firms. Salant et al. (1996) and von Reichert and Rudzitis (1992) found that the amount of crime was a factor that influenced individuals' decisions to migrate to a community that they perceived would provide a better quality of life.

Researchers within the criminal justice field conclude that perceptions of crime and security vary with site characteristics and socioeconomic conditions and thus, fear of crime does not always accurately reflect actual crime rates. Instead, fear of crime is often derived from incomplete knowledge of crime rates, observable evidence of disorder, and prejudices arising from neighborhood change (Skogan 1986). Other studies conclude that the direct effects of the physical environment on crime rates range from small to moderate (Taylor and Gottfredson 1986).

In short, selected crime statistics obtained from the Federal Bureau of Investigation indicate that lower-density developments, such as suburban and rural areas, have lower crime rates than high-density urban areas. Empirical studies that have examined the relationship between crime and density, however, have found mixed results—increased density does not necessarily result in higher crime rates. The mixed results may be a factor of how individual studies define and measure crime and crime rates. There appears to be agreement that suburban residents perceive themselves to be safer than their urban counterparts.

Although the literature appears to demonstrate, at best, correlation between density and crime, it does not demonstrate causality between sprawl and low crime rates. Studies have found that the effect of physical environment on crime rates ranges from minimal to moderate and that crime is more a factor of socioeconomic conditions than density. An argument might be made that sprawl reduces crime rates in a round-about way—sprawl is correlated with higher incomes which, in turn, are often correlated with greater spending on home protection and public safety. This argument, however, does not demonstrate that sprawl causes lower crime rates.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

IV.B.3. Reduced Costs Of Public and Private Goods

Allegation/Basis

Many households find the cost of public services and some private services in suburban locations a better value.

Literature Synthesis

The alleged benefit for *public* services substantially overlaps the alleged benefits reviewed under the heading Social Issues in this literature review. Two of the alleged benefits discussed there are germane here:

1) The ability of jurisdictions to define a relatively homogeneous population with relatively similar service needs (which also provides opportunities for both economies of scale and concentration), and the ability to drop services not needed by the homogeneous population (i.e., social services for low-income households).
2) The ability to have different tax levels and service qualities.

There is an ongoing professional debate about the institutional structures by which public services are most efficiently and fairly provided, and a large body of literature on the subject. Not surprisingly, the poles of the debate are occupied by those who believe in the efficiency of markets and those who believe markets operate imperfectly without government intervention.

For *private* goods, there is ample anecdotal evidence that big box retailers make their money by high volumes on low margins, which for consumers means low cost. The growth of these retailers (e.g., Wal-Mart, Home Depot, Costco) is evidence of demand and suggests that they are giving consumers more of what they want. Additional anecdotal evidence suggests that many people who would oppose such retailers in their neighborhoods are some of the same ones who drive, often substantial distances, to shop at these stores in other parts of a region.

A few central cities have seen new discount retailing. In most cases, however, the development has occurred on underutilized industrial parcels whose zoning either defines the retail uses as compatible or makes variances easy to receive. In these cases, low-value land is still the primary factor allowing the development to proceed.

There is reasonable evidence to conclude that people want goods at lower prices in lower-density parts of metropolitan areas. As with other effects, whether sprawl *causes* this effect is a matter of interpretation.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

IV.B.4. Fosters Greater Economic Well-Being

Allegation/Basis

As an outcome of a free market, sprawl benefits from the market decisions made by individual households and firms to maximize their welfare (as measured by utility or profit).

Literature Synthesis

In the New Jersey impact assessment, Burchell et al. (1992a) found that New Jersey could accommodate similar magnitudes of population and employment growth under both trend and plan development patterns. Distributional patterns would differ, however. Plan development would direct more jobs to urban and rural centers and fewer to suburban areas than trend.

Sheppard (1988) relates sprawl to the economic well-being of residents. Sheppard found that an increase in space available to a particular class of residents results in lower rents at all locations, increased “suburbanization” for all classes, and increased utility for all classes. Sheppard cautions the reader, however, that the results consider neither externalities nor the public good associated with the exercise of development controls.

Most authors argue simply that sprawl must maximize welfare because it results from free-market decisions (Gordon and Richardson 1997, 99). The benefits of sprawl that affect economic well-being are most often addressed in arguments against policies to limit sprawl. These arguments are based on the considerable literature that shows that increased density increases the cost of land. It is argued that an increase in density will reduce job growth and economic development opportunity by increasing the cost or limiting the number of sites available for commercial development, and by increasing the cost of housing which in turn will limit the supply of labor (ECO Northwest 1994).

Growth controls raise housing prices in communities where they are established.

There is considerable evidence that measures to control growth cause the price of land to increase. Shilling et al. (1991) found that state land-use controls both restrict the supply and increase the demand for residential land, driving up its price. Brueckner (1990) cites a large empirical literature documenting the effects of growth controls on housing and land markets.

His evidence points to the fact that growth controls raise housing prices in communities where they are established (Dowall and Landis 1982; Elliot 1981; Katz and Rosen 1987; Schwartz et al. 1981; Schwartz et al. 1989).

Most of the literature that addresses the impact of growth controls on land prices focuses on the residential land market. There appear to be very few articles that address the impact of sprawl, or
measures to control sprawl, on commercial land markets, the level of employment growth, or wage income. While there are logical reasons to suspect that uninhibited growth fosters more employment and wage growth than limited growth, the literature does not document this at all.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?		X		

3.7 SOCIAL ISSUES

V.A. Sprawl's Alleged Negative Effects

V.A.1. Fosters Suburban Exclusion

Allegation/Basis

Suburban exclusionary zoning increases the concentration of low-income households in certain neighborhoods.

Literature Synthesis

There is some disagreement about the degree to which suburban exclusionary zoning is responsible for poverty concentrations in core-area neighborhoods. Some observers believe other factors are more important in producing such neighborhoods. These other factors include negative behavior patterns among the residents that make them unwelcome elsewhere; the concentration of deteriorated, very low-cost housing in such neighborhoods which attracts people who cannot afford better accommodations; the concentration of public housing units in such neighborhoods; the lack of public transportation in suburban areas that makes it difficult for poor persons without cars to live there; and the desire of poor households to live together in neighborhoods where public services aiding the poor are more easily accessible.

In contradiction, recent findings in New Jersey from the New Jersey Council on Affordable Housing (COAH) and similar findings from the Gautreaux (Chicago) and Special Mobility Program (SMP) (Cincinnati) studies indicate that those who occupy affordable housing in more suburban locations take on the employment characteristics, ambition levels, and success rates of the population of those jurisdictions (Wish and Eisdorfer 1996; Davis 1993; Fischer 1991). In New Jersey, close to 15,000 affordable housing units have been built and occupied as a result of legislation emanating from the series of *Mt. Laurel* cases in that state. Occupants of these housing units are employed, doing well at local schools, and integrated without incident in neighborhoods they would not have had access to without the court decisions.

The Gautreaux and Special Mobility Program studies show that residents moving from the central city to the suburbs using housing vouchers have higher rates of employment and higher salaries, and their children have better school attendance and higher grades than families who choose not to move. While the confounding issue of self-selection is clearly present here—i.e., the successful and ambitious families are the ones that opted to participate in the moves—a growing body of literature that indicates "place" matters. There is a "rub-off" effect of place wherein success patterns can be communicated by residents to newcomers who specifically wish to improve their current economic and social positions. (Poisman and Botein 1993).

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

V.A.2. Fosters Spatial Mismatch

Allegation/Basis

The resulting "spatial mismatch" between where most new jobs are being created (far-out suburbs) and where many low-skilled workers must live (inner-city neighborhoods) aggravates high rates of unemployment in inner-city neighborhoods.

Literature Synthesis

John Kain (1992) was one of the first to examine whether a mismatch exists between the increase in lower-skilled and otherwise attainable jobs in the suburbs and the high levels of unemployment of residents in central cities who should be able to access these jobs. Spatial mismatch has also been examined by sociologist John Kasarda (1990) and William Wilson (1987) and economists Keith Ihlanfeldt and David Sjoquist (1990). Although the original literature related the mismatch to black workers of all ages, later studies focused on the spatial mismatch as it affected young black workers. Race as the causative agent is the main focus of inquiry throughout most of the studies mentioned above. In other studies by Bennett Harrison (1974a) and John Kasarda (1990), causes of the mismatch (which according to them may not be spatial) are extended to the inadequate skills and education of young black workers, and limited transportation or access to transportation. Findings on spatial mismatch, although not always consistent in unearthing a spatial component (see Bennett Harrison [1974a], David

Ellwood [1986], and Jonathan Leonard [1987]), are persistent in their specification of a mismatch of some type.

The reality of this mismatch is a population desiring to be employed in one location and available jobs going unfilled in another. Often, the unfilled jobs are lower order jobs that are not worth accessing by public transit if the prospective worker must also pay for child daycare services in order to reach the job.

The confluence of elements that creates spatial mismatch is so complex that sprawl versus more compact development patterns probably play only a small role.

Other jobs similarly located in the suburbs may require skills that applicants, even after training, cannot meet. Or they may be jobs that casual workers available during the summer or during college breaks can easily meet without training.

The confluence of elements that creates spatial mismatch is so complex that sprawl versus more compact development patterns probably play only a small role. Spatial mismatch will grow to be a major issue with significant consequences as workfare replaces welfare. Moreover, the relationship between sprawl and central city unemployment rates, the bottom line issue of the above discussion, is even more complex than relationships between sprawl and spatial mismatch.

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?	X			
Is it strongly linked to sprawl?		X		

V.A.3. Fosters Residential Segregation

Allegation/Basis

Residential segregation by race and income is greater under sprawl than where less fragmented governance over land uses exists.

Literature Synthesis

There is only partial agreement about this allegation. Such a small number of metropolitan areas without fragmented governance over land uses exist in the United States that statistical testing of conditions in them versus conditions elsewhere probably are not valid.

Those states and regions that have made overt efforts to provide affordable housing in locations where it has not before existed are achieving integration in those locations.

Yet coming at this issue from another direction, those states and regions that have made overt efforts to provide affordable housing in locations where it has not before existed are achieving integration in those locations. In New Jersey, where a municipality must provide its fair share of affordable housing or lose its right to zone, racial and ethnic integration is taking place in what were once predominantly white outer-ring neighborhoods. New Jersey's affordable housing program requires that those who fill municipal quotas come from outside the municipality's boundaries but inside its commuting region. There are strict advertising and queuing requirements that ensure that minority households in central cities have an equal chance to occupy affordable housing in the suburbs. With these kinds of mandates, integration of neighborhoods moves quickly and directly (Wish and Eisdorfer 1996).

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?			X	

V.A.4. Worsens City Fiscal Stress

Allegation/Basis

Under sprawl, central city governments become fiscally strapped or "squeezed," because they must provide costly services to large numbers of very poor households, while the properties owned, occupied, or patronized by such households produce relatively low per capita tax revenues.

Literature Synthesis

The concentration of very poor households within inner-city neighborhoods is surely not caused solely by suburban sprawl; many other causal factors largely unrelated to the specific form of growth within a metropolitan area also contribute to this result. Unfortunately, it is probably impossible to decide scientifically how to allocate "responsibility" for this outcome among these causal factors—a fact which presents an obstacle to "proving" that sprawl contributes significantly to this outcome.

Most of the central city fiscal deterioration forces described above, while largely independent of development patterns, certainly need the defining characteristics of sprawl to operate.

Most of the central city fiscal deterioration forces described above, although largely independent of development patterns, certainly need the defining characteristics of sprawl to operate. Fragmented governments in competition with each other for the "better" land uses create fiscal stress for those governments that cannot compete (Downs 1994).

(See also Public-Private Capital Quality Costs—Negative Impacts—Worse Fiscal Impacts).

Literature Synthesis Matrix

	+2 *General Agreement*	**+1** *Some Agreement*	**0** *No Clear Outcome*	**–2** *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?		X		

V.A.5. Worsens Inner-City Deterioration

Allegation/Basis

A self-aggravating downward spiral of negative conditions and the consequent withdrawal of viable resources occurs in inner-city neighborhoods, making them continually worse off.

Literature Synthesis

The most significant causal relationship to central city abandonment was the amount of housing built outside the central city.

A study of residential abandonment in cities nationally (Sternlieb and Burchell 1977) investigated numerous causal relationships including:

1) Other abandoned structures on the block.
2) Race of tenant and owner.
3) Commercial use of part of the property.
4) Racial and economic characteristics of neighborhood and city.

The study found that the most significant causal relationship to central city abandonment was the amount of housing built outside the central city yet inside the city's metropolitan area (Sternlieb and Burchell 1977).

To the degree that significant amounts of housing are built farther out in the metropolitan area and the occupancy costs of this housing are comparable to, or cheaper than, existing housing, this new housing will be sought in preference to closer-in housing (Schafer 1975).

Unfortunately, however, as with fiscal stress, it is probably impossible to decide scientifically how to allocate "responsibility" for this outcome among multiple causal factors.

(See also Quality of Life—Positive Impacts Foster Free-Market-Making).

Literature Synthesis Matrix

	+2 *General Agreement*	+1 *Some Agreement*	0 *No Clear Outcome*	–2 *Substantial Disagreement*
Does this condition notably exist?		X		
Is it strongly linked to sprawl?		X		

V.B. Sprawl's Alleged Positive Impacts

V.B.1. Fosters Home Rule

Allegation/Basis

Sprawl keeps government decisions about land use at the local level, where individual citizens have much more chance of influencing the results than they do where regional decision making predominates.

Literature Synthesis

The literature dealing with the merit of home rule praises its "small government" democratic responsiveness, as is illustrated in the following quotations:

> Others came to suburbs for better schools. This has been due, at least in part, to the responsiveness of these schools to parental expectations, rooted in turn in the smaller size of many suburban school districts. Indeed, in an age primarily given over to state centralization, the suburbs have encouraged a countervailing decentralization governance, forcing a healthy kind of competitiveness onto local governments. (Carlson 1996, 34-5)
>
> The trend in many places has been for cities to incorporate their surrounding suburbs, creating mega-jurisdictions without local identity and administrative nimbleness. This is a bad idea. Instead, cities ought to be breaking themselves into smaller political units that enjoy a degree of social consensus where governing can be done flexibly and with less impersonality. (Kotkin 1996 7, 60)

Obviously, the literature is divided on this point. One statistic beyond refute is that there is little growth in regional governments on a national basis, and although municipalities or counties may be willing to join together to distribute one or another carefully selected public services, they appear unwilling to join together for common governance. Further, on a national basis, the number of regional school districts currently desiring to split apart is greater than the number of school districts currently desiring to join together (Petersen 1996).

One statistic beyond refute is that there is little growth in regional governments on a national basis.

Literature Synthesis Matrix

	+2 *General Agreement*	+1 *Some Agreement*	0 *No Clear Outcome*	–2 *Substantial Disagreement*
Does this condition notably exist?	X			
Is it strongly linked to sprawl?		X		

V.B.2. Enhanced Municipal Diversity and Choice

Allegation/Basis:

Sprawl provides citizens with a great variety of localities with differing tax-levels, public service qualities, and housing costs, thereby increasing the range of choice available.

Literature Synthesis

There is reasonable agreement that housing costs, public services (primarily education), tax levels, and housing stock aesthetics of a community form the bundle of goods that is bid for in community selection. Within a metropolitan area, citizens have significant choices of communities, and within a fragmented metropolitan area, they have even more choices.

Sprawl's contribution to diversity in choice is the massive amount of reasonable alternatives (not best or worst) that it offers the locational consumer.

Those who "shop" for communities take all of the elements listed above into account before making a locational decision. Sprawl's contribution to diversity in choice is the massive amount of reasonable alternatives (not best or worst) that it offers the locational consumer.

(See also Home Rule section.)

Literature Synthesis Matrix

	+2 *General Agreement*	+1 *Some Agreement*	0 *No Clear Outcome*	–2 *Substantial Disagreement*
Does this condition notably exist?	X			
Is it strongly linked to sprawl?		X		

3.8 OVERALL SUMMARY OF THE SPRAWL LITERATURE

The literature synthesis is summarized in Figure10. Evident from that table is that the field tends to be more prolific on criticisms (costs) than on benefits. It is also obvious that there are more 'physical' than 'social' or 'environmental' impacts of alternative urban forms and development patterns. These physical characteristics include travel, especially by automobile; greater consumption of land; and infrastructure costs. By contrast, there is much less literature and even less agreement in the literature on such matters as “stress” or “community” due to sprawl.

With respect to the issue of whether certain costs and benefits are “strongly linked to certain development patterns, such as sprawl” (holding aside the issue of causality), there are a few areas of high consensus, such as sprawl’s link to greater automobile travel and consumption of more farm and frail lands. By contrast, there is “no agreement” on many fronts, such as whether housing and land are more expensive under sprawl.

For our purposes, the divergence of opinion which exists on a variety of the impacts of alternative development patterns suggests the need for both caution and flexibility in the application of specific methods to estimate these costs in connection with local and metropolitan development plans. At the same time, agreement on the linkage between alternative development patterns and certain other costs appears sufficient to endorse their use for planning purposes.

In the chapter which follows, we visit the framework of costs outlined in Chapter 2. We review the basic social, economic and environmental elements covered in this chapter as areas of difference of concern. We suggest ways to think quantitatively about the relationship between these topics and introduce a simplified method of accounting for these impacts.

For illustrative purposes, we select from among the many sources of data a small number of data sets and findings which enable us to illustrate a specific method for comparing the costs of alternative development patterns. The pages which follow contain the details of this method.

Figure 10: Matrix Synthesis of the Literature on Sprawl

Substantive Concern	Does Condition Notably Exist?				Is It Strongly Linked To Sprawl?			
	+2 General Agreement	+1 Some Agreement	0 No Clear Outcome	-2 Substantial Disagreement	+2 General Agreement	+1 Some Agreement	0 No Clear Outcome	-2 Substantial Disagreement
I. Public-Private Capital and Operating Costs								
A. Alleged Negative Impacts								
1. Higher infrastructure costs	X					X		
2. Higher public operating costs		X					X	
3. More expensive private residential/ nonresidential development costs		X					X	
4. More adverse public fiscal impacts		X				X		
5. Higher aggregate land costs		X				X		
B. Alleged Positive Impacts								
1. Lower public operating costs		X					X	
2. Less expensive private residential/ nonresidential development costs		X				X		
3. Fosters efficient development of "leapfrogged" areas			X				X	
II. Transportation and Travel Costs								
A. Alleged Negative Impacts								
1. More vehicle miles traveled (VMT)	X				X			
2. Longer travel times			X				X	
3. More automobile trips	X				X			
4. Higher household transportation spending			X				X	
5. Less cost-efficient and effective transit	X					X		
6. Higher Social costs of travel		X				X		
B. Alleged Positive Impacts								
1. Shorter commuting times			X				X	
2. Less congestion			X		X			
3. Lower governmental costs for transportation			X				X	
4. Automobiles most efficient mode of transportation		X			X			

Figure 10 (Continued) Matrix Synthesis of the Literature on Sprawl

	Does Condition Notably Exist?				Is It Strongly Linked To Sprawl?			
Substantive Concern	+2 General Agreement	+1 Some Agreement	0 No Clear Outcome	-2 Substantial Disagreement	+2 General Agreement	+1 Some Agreement	0 No Clear Outcome	-2 Substantial Disagreement
III. Land/Natural Habitat Preservation								
A. Alleged Negative Impacts								
1. Loss of agricultural land	X				X			
2. Reduced farmland productivity		X					X	
3. Reduced farmland viability			X				X	
4. Loss of fragile environmental lands	X				X			
5. Reduced regional open space			X				X	
B. Alleged Positive Impacts								
1. Enhanced personal and public open space		X					X	
IV. Quality of Life								
A. Alleged Negative Impacts								
1. Aesthetically displeasing		X					X	
2. Lessened sense of community		X					X	
3. Greater stress		X				X		
4. Higher energy consumption			X				X	
5. More air pollution		X					X	
6. Lessened historic preservation		X					X	
B. Alleged Positive Impacts								
1. Preference for low-density living	X					X		
2. Lower crime rates		X					X	
3. Reduced costs of goods and services		X					X	
4. Fosters greater economic well being		X				X		
V. Social Issues								
A. Alleged Negative Impacts								
1. Fosters suburban exclusion		X					X	
2. Fosters spatial mismatch	X					X		
3. Fosters residential segregation		X					X	
4. Worsens city fiscal stress		X				X		
5. Worsens inner-city deterioration		X				X		
B. Alleged Positive Impacts								
1. Fosters home rule	X					X		
2. Enhances municipal diversity and choice	X					X		

4.0 ILLUSTRATION AND APPLICATION OF A FULL SOCIAL COST FRAMEWORK

4.1 OVERVIEW

This chapter describes the organization and implementation of a prototype model for estimating the Full Social Cost of Alternative Land Development Scenarios (SCALDS) at the regional level. The model has been developed using software that is commonly available to most Metropolitan Planning Organizations (MPO), the computer spreadsheet (EXCEL). The prototype model consists of 18 interconnected spreadsheets, which produce an aggregate estimate of the full costs of regional land use scenarios.

This model builds on the three components, identified at the close of Chapter 2, which we consider to be essential to a full cost framework that has potential for practical application. First, this model pays particular attention to infrastructure costs, since these are the costs with which many citizens and elected officials are most familiar. Secondly, it acknowledges both public and private costs. (While an ideal framework would further differentiate private costs into those borne by businesses and consumers, this model affords opportunities for further development in these directions at a future date.) Third, it deals with both internal and external costs, with external costs being accounted for through several elements of the model.

The development of alternative land use scenarios requires that the MPO have several copies of the spreadsheet files, each named for the scenario that it estimates. The individual scenario files need to be appropriately modified so that they will calculate the cost of the alternative land use pattern based on the appropriate modifications of model variables. To compare the relative cost of two or more scenarios, it is necessary to summarize the results from these two files outside the model process. This can be done simply by pasting Tables 17 and 18 from each scenario into a third spreadsheet and then comparing the summary totals in new tables and/or charts.

The SCALDS Model is not intended to be the definitive solution or the cookbook for estimating costs, but a guide to how a metropolitan area might approach this project. Additional tables can be added and local cost factors substituted for the national averages used in several situations. One approach to starting the modeling process is to estimate a full cost base scenario using the default national cost estimates. Then additional scenarios can be developed, possibly using selected local costs if available.

The SCALDS Model has three general calculation paths. The physical development path (Tables 3 through 8) models the consumption of land, the projected mixture of new housing units, the local infrastructure cost and annual operating cost of sewer, water and storm water services. It is also possible to project the average amount of non- residential building space needed to support new development. The total travel cost path (Tables 9 through 12) models the annual operating cost of peak and non-peak travel on a passenger miles traveled (PMT) basis.

The third path (Tables 10 through 16) models the air pollution produced by transport mode, the energy consumption by transportation and the energy consumed by residential land use in non dollar units. The residential energy consumption contains a factor that approximates the non-residential energy consumption. This path also estimates the cost of the energy consumed by transport and residential land use. However the transport related energy costs are not carried forward to the summary Tables 17 and 18 because this cost has already been included in the model elsewhere.

Finally, the third path has an illustrative table, number 16, that shows a short term projection of the increase in new students from the construction of new housing units. This table estimates the marginal change in the number of school age children and the marginal change in school operating cost. The results from this table are not carried forward to the summary tables because the marginal cost change estimates are only good for the short run. In order to get a good estimate of these projected changes in school age children and school operating cost it will be necessary to undertake a separate modeling process outside of the SCALDS Model framework and then add the results of this process back into the SCALDS Model.

The balance of this chapter is devoted principally to an explanation of each of the steps or elements in the model. To test the general reliability of the model system, we illustrate the workings of the model by using data taken principally from one metropolitan area, Portland, Oregon and secondarily from another, Boulder, Colorado. Thus, the chapter includes not only an explanation of the model but also an illustration of its use.

The sample data used in this prototype application was taken principally from the background documents and official projections done by the Metropolitan Service District (Metro) in Portland Oregon as part of their new regional framework plan. The data is aggregated for the three Oregon counties in the MPO. We produced two example scenarios for Metro, which will be discussed later in this report.

4.2 DEMOGRAPHICS IN THE SCALDS MODEL: SOME CAVEATS

The SCALDS Model is not designed to show the demographic variations that occur within sub-areas of a metropolitan area and which can produce jurisdictional or sub-area variations in the estimated full cost of development. The estimation of sub-area or jurisdictional marginal costs needs to approached more rigorously than the estimation of MPO level estimates.

The population of a metropolitan area as a whole has distinct age/sex/household size characteristics that do not change in response to policy variables such as the projected mixture of housing unit types. On the contrary, the mixture of new housing units constructed is directly related to the demographics of the population purchasing or renting new housing units.

The model itself does not forecast changing demographic patterns over time. If a metropolitan area expects a major or systematic shift in regional demographic patterns to occur during the forecasting period, exogenous adjustment should be made to the model inputs to reflect the predicted changes, and these adjustments should be well documented.

An alternative approach to this problem would be to estimate the full cost of development using constant demographic patterns and then estimate the cost making the anticipated changes in the region's demographic patterns. This will allow the analyst to approximate the impact of the change in cost.

A good population forecast is an invaluable resource for the SCALDS Model. It allows the analyst to make informed adjustments to policy variables, such as the new housing mix, which affect the total cost of development in a metropolitan area. In the same vein, good inventories of the existing developed environment improve the overall operation of the model. However, the analyst should remember that it is possible to make changes in the housing mix that mathematically implies changes to the age structure of the population or the average household size in the region. The demographic pattern of the region is not changed by simply changing the mixture of new housing types built in the region. Therefore the analyst should adjust the mix of new housing units within the context of the expected average household size and projected rate of household formation.

MPO's have a substantial body of research that they can draw on to modify the unit costs used in the SCALDS Model or to enhance the model by adding new cost calculation modules to the Model. Two good general overviews of transportation cost data were reviewed extensively during the development of the SCALDS Model, Todd Litman (1995) and Mark Delucchi et al, (1996a, 1996b, 1996c). The latter report has been prepared for FHWA. MPO's also have access to large amounts of data from the US Census, various state agencies, city and county governments. Data sources are numerous. We have incorporated data from many different sources in the Model. MPOs have the option to carry this process further and adapt the SCALDS Model to more closely match local conditions.

4.3 DESCRIPTION OF MODEL ELEMENTS

In this section we describe each of the elements in the SCALDS Model. Each element is linked to a specific Table in Appendix B. We identify its purpose and function. We cite the sources of data on which the element is based. We describe the relationships and formulas imbedded in the model in verbal and quantitative terms. We identify the relationships between this and other elements of the model.

All the elements of the SCALDS Model are shown in Table 19, Appendix B. Further, the links between the different elements are diagrammed. Table 19, Appendix B should be a quick guide or "road map" to the discussion which follows.

Consumer Price Index - Table 1 (See Appendix B for all Tables)

The starting point for the SCALDS Model is Table 1 – Consumer Price Index (CPI). The Model uses default cost data from a number of different years to estimate the cost of alternative land use patterns. It is, therefore, necessary to adjust the costs used in the model to remove the effects of inflation. This is done by means of an inflator factor or deflator factor, which adjusts the costs taken from different national studies to base year dollars. The Base Year is the year (1995) that is used as the base in the analysis. The default cost in the model has been adjusted to base year of 1995. If an analyst wishes to use a different base year for the value of money, it will be necessary to deflate or inflate the cost in various portions of the spreadsheet model to the new base year.

The CPI used in the model is the Consumer Price Index for All Urban Consumers for All Goods. This index was chosen because it is a general national indicator of inflation and it smoothes out local economic fluctuations. The CPI shown in Table 1 is from January of each year. The CPI contains a unique CPI factor for each month in the year. A CPI for a different month could be substituted if this meets some other MPO criteria. The CPI for All Urban Consumers for all Goods (1982-1984=100) is available from the Bureau of Labor Statistics on their web site *(http://stats.bls.gov/cgi-bin/surveymost - Series ID CUUR0000SA0).* This site contains the CPI on a monthly basis for the time periods from 1913 to present.

Indexing costs from different years to the base year is done using the following equation. In this example the base year is 1995 and the original year or the year of the cost estimate is 1987.

$$\text{Base Year Cost 1995} = \text{Original Year Cost 1987} * \left(\frac{\text{Base Year CPI1995}}{\text{Original Year CPI1987}} \right)$$

There are few options available for adjusting costs to base year values. A metropolitan area could elect to use one of the other forms of the CPI such as the Engineering News Record material price index which is very good for forecasting capital intensive infrastructure cost. Other cost indexes exist but none of them address overall issues of inflation in urban cost as well as the CPI.

The CPI requires very little effort on the part of the MPO in terms of data maintenance. It can be updated as necessary by down loading the newest data from BLS. This is only necessary if the MPO wishes to use a different source of cost data that is estimated during a year for which the MPO does not currently have a CPI factor. The other possible use of the CPI is to move all of the costs in the Model to a new base year such as 1997. The MPO simply needs to insure that it has adjusted each of the costs described in the following sections from its original year costs to the new base year cost to accomplish this transition.

CPI cost adjustments are not made automatically in the prototype model. It is necessary to apply the cost indices to data from the base year cost used by an MPO.

MPO Growth Forecasts – Table 2

The MPO Growth Forecast is a key portion of the SCALDS Model. All of the remaining spreadsheets in the model are linked directly or indirectly to the data entered into this table and all of the cost estimates flow from these projections.

Table 2 contains much of the basic planning data that a metropolitan area develops during the normal course of creating a transportation planning model for an urban area. These data are developed exogenously or outside of the SCALDS Model and are brought into the model by the MPO. All of the data are aggregated at the MPO level. This aggregation can mask local or sub-regional demographic changes, trends and differences.

The data needed to fill this table can be divided into the following general categories:

- Total Population and related aggregate factors such as average household size for the MPO.
- Total Number of Housing Units, the MPO average vacancy rate and the MPO multifamily / single family housing split.
- Total MPO employment and the retail / non-retail employment split.
- Total Vehicle Miles Traveled (VMT) – VMT is needed for some portions of the travel costing modules such as the Federal/State Highway Investment portion of total travel cost. Travel costs, however, are modeled on a Passenger Mile Traveled basis in most portions of the model.
- Road system summary data at the MPO level including a factor to estimate the consumption of land for the road right of way.

Housing and population data used by the Model is expected to be at about the same level of generalized detail as the data that is maintained by the MPO. It is particularly important to have an accurate inventory of the existing building stock by type before making projections of future growth. There is little that can be done to substantially change the nature of the existing housing stock in the short run. It is also unlikely that new development will completely change the nature of the housing stock during a twenty year planning period. The existing housing stock, like existing demographic patterns, is a given in the modeling process. New development and new growth create only marginal changes in both population and housing.

The Model allows the analyst to divide the projected housing stock into several categories by building type. These categories facilitate the estimation of different costs of development associated with different land use patterns. The categories are one of the areas where local government policy can influence the nature of development and the full cost of development. The ability of the model to estimate the cost of development depends in large part on the data supplied to it in these modules.

NOTE: The use of different housing stock types in this model is for convenience in the calculation of aggregate, regional impacts. Because different types of housing stock have been linked with different types of costs, it is convenient and appropriate for use in the aggregate level of analysis. However, use at a sub-regional or local level is likely to be misleading or wrong for several reasons. First, local costs vary within regions. Secondly, since housing stock is a supply variable (not a demand in itself), it is not possible to vary regional costs by varying the regional housing stock. While local policies governing housing type, density and amenities may affect the demographic characteristics of local or neighborhood residents, at the regional level differences disappear; the forces that control regional demographic changes are not influenced (and certainly not influenced easily) by manipulating housing unit size or the number of bedrooms.

It is appropriate to note again that the population forecasts used in the model are summary forecasts that show general trends, such as a decline in average household size. The model assumes that any demographic trends that are occurring in the metropolitan area population are occurring outside the model process and will not be affected by the model's assumptions (e.g., about housing stock).

Data for this model is available from the MPO itself, and from secondary data sources such as the US Census (population and housing), the state employment agency (ES202 files on covered employment), local planning agencies on land areas, housing units, miles of street etc. It is likely that most of this information exists in a metropolitan area. But the MPO may need to invest considerable effort in the process of gathering, inventorying, classifying and organizing the available data, if this process has not already been accomplished. The MPO should establish a standardized set of databases based on relatively stable geographic boundaries such as census tracts. It is important to have agreements with local governments on the continuous collection of the data on new development. While it is a problem to constantly maintain databases, it is harder to rebuild them from scratch whenever it is necessary to undertake a new study. Attention to database design and maintenance is one of the best long-run investments that an agency can make.

The data used in this sample model application was taken from the following sources: Metro (1997a and 1997b).

Projected Housing Mix - Table 3

This table contains the detailed housing mix for the region that is the basis for residential infrastructure cost and land consumption. The table is an elaboration of the basic housing data added to the model in Table 2.

The model will work with a housing mix that designates housing units only as single family or multifamily. However, the model will provide a significantly better estimate of the cost of a particular land use pattern if it has a more detailed mixed of housing unit types and densities to work with.

The accurate and detailed inventory of the existing housing stock is also a key component used in several other tables to estimate regional operating costs. If local data on the housing mix in the metropolitan area is not readily available, a good place to start looking for data is the decennial census of housing. Local government building permit data is also a valuable source of data on the changes that have occurred since the last census.

Data on the details of the housing mix can be obtained from the decennial census (1990 Census of Housing) and from city and county building permit data. An additional distribution of housing type has been estimated from the Public Urban Microdata Sample for a metropolitan area. Local homebuilder organizations may be able to provide some additional detailed information on the composition of new single family housing construction trends.

Numerous national studies have reviewed the cost of development by housing type and logically concluded that the cost of development and the infrastructure required to support a particular type of development is directly related to the density of development and the type of unit constructed. The different studies produce different estimates of the cost per unit depending on the assumptions and the details of the cost included in the analysis.

The costs used in the SCALDS Model are taken from a study by the Urban Land Institute that is cited in the discussion on Table 4.

There are two elaborations of the SCALDS Model which could be developed and connected to the model through the housing mix data in Table 3. The first elaboration is the estimation of the cost of new residential construction associated with different land development patterns. To estimate the cost of new construction it would be necessary to develop construction average costs per square foot or per unit for each type of housing. If average cost per square foot is used, then it is necessary to also estimate the average size of the new units constructed.

NOTE: The types of new housing units constructed and their size is going to be driven by the demographics of the purchasers and renters of new housing. For example an urban area, which is experiencing a significant in-migration of retired couples, will not contain many new single family houses with three or more bedrooms.

A second elaboration could involve estimating the number of housing units needed by number of bedrooms per unit. This is a variation on the cost of housing because the more bedrooms in a housing unit, the larger and more costly the unit. This type of analysis would again be directly linked to a detailed demographic forecast that is exogenous to the SCALDS Model. Such a forecast would provide a more detailed picture of the projected housing need and would be more sensitive to the demographics of the future urban population. But this type of forecast needs to be the subject of additional research before a clear methodology is available to add to this model.

NOTE: The model does not address housing price issues (relationships between supply, demand and price) or any issue related to the income distribution of the existing or future population of a metropolitan area. While these issues are important they are also too complex to be addressed in a basic model like the SCALDS Model.

The data used in the sample model was estimated from the information available in Metro's, Urban Growth Report - Revised Draft , Metro (1997b).

Infrastructure Cost by Housing Type – Table 4

This table estimates the cost of infrastructure associated with residential construction. The construction of new local government infrastructure in most urban areas is focused in developing residential areas. Substantial portions of the annual expenditures for new streets, sewers, water line and storm drainage facilities are made by the development community during the land development process. It is difficult to estimate the average expenditures for infrastructure per new housing unit by structure type using local data because these expenditures are not normally made directly by local governments; but if good local records are available, a metropolitan area may wish to estimate the cost of this infrastructure based on local information.

The SCALDS Model uses average costs for infrastructure by housing unit type derived from a study by the Urban Land Institute - Frank (1989), as cited in Burchell (1997a). The costs estimated by this study have been converted from 1987 dollars to 1995 dollars using the CPI.

Our sample model application uses the basic infrastructure cost for each service. The Model cost estimates can be increased to reflect differences in the nature of the adjoining land and the distance from major facilities such as water reservoirs, sewerage treatment plant and streams that handle storm water run off. Each of these factors can change the overall cost of the infrastructure need to serve new residential development. Table 4, Columns C and D, contain cost factors that express the differences in development costs associated with compact development and leapfrog development. Columns E and F contain additional costs associated with development located some distance from major infrastructure facilities such as sewer trunk lines or water transmission mains. At the MPO level these variations in cost are difficult to use. They will be more useful in future model extension at the subregional level.

NOTE: The MPO using the SCALDS Model needs to review the infrastructure cost estimates for the low density and very low density single family residential uses. It is not uncommon for these land uses to be developed using septic tank instead of public sewer, and wells instead of public water facilities. The model does not currently contain an estimate of the capital cost of installing these private systems. If this type of development is commonly supported by private infrastructure such as wells or septic tanks, a metropolitan area should obtain estimates of the average cost for the installation of these systems from installers of these systems who work in and around the urban area, and use those estimate for the average capital cost of this form of development. Operational cost of these services (wells and septic tanks) also differs from the operating cost of water service in Table 7, and thus it should be estimated based on local well and septic tank service costs.

The best sources of local data on the cost of infrastructure related to local residential development is city and county planning and engineering offices. These records should provide an estimate of how much infrastructure was installed with each new residential development. If there are large variations in the cost estimates for these improvements, the MPO could collect the data on the quantity of materials used by type and estimate the cost of the infrastructure using the cost factors found in the ENR (Engineering News Record). These cost estimates are updated continually and provide a third party source for determining the cost of infrastructure.

The Urban Land Institute report does not have a separate estimate of the infrastructure cost associated with “High Rise Development” of 60 units per acre or more. This form of development is normally a very small portion of the total development in an urban area. The costs are assumed to be the same for High Rise Development as they are for Mid-Rise Development (30 units per acre). If better data on high rise infrastructure costs are available locally, it is recommended that the local data be used.

The collection and maintenance of data on infrastructure cost can be a relatively formidable task in an urban area. One method to collect and maintain this type of data is creation of a GIS based facilities management system. The maps and data bases developed as part of such a system are a valuable resource to the local water, sewer and storm water service providers and a good source of basic planning data at the MPO level. The development of a cooperative or intergovernmental GIS system can help spread the cost of developing and maintaining a GIS. The collection of data is not adequate justification by itself for the cost and effort that is required to create a GIS system. It is merely another use of the data that can be developed from this type of system.

Detailed Employment Data – Table 5

This table is a more detailed presentation of the regional employment projections, which are the basis for non-residential land consumption and water and sewer demand estimates.

These data are all developed locally by the MPO. The economic growth of the urban area is the driving force behind overall regional growth. Historic data in this table is available from a variety of sources including the US Census, County Business Patterns, and state data on covered employment (ES 202 file). Projected employment is available from the Bureau of Economic Analysis. These data sources are all good starting points for a metropolitan area employment forecast.

This particular data set does not lend itself to local maintenance of data. The one exception is site level data from the ES 202 files. MPO's may be able to obtain these data, subject to agreements on confidentiality. The ES 202 files commonly require some level of data clean up and geocoding before they are usable by a metropolitan area. The ES 202 file commonly has data on about 90 percent of the employment in an urban area. If a MPO decides to use these data it should be updated at regular intervals such as annually, biannually or every 5 years in order to provide time series data for future employment projections.

The data used in the sample model application was taken from the following sources: Oregon Employment Division, (1991), Metro, (1997b), Metro, (1997a). The allocation of employment into industry sectors is based on the 1990 industry sector proportions and is not a Metro projection.

Non Residential Development Mix – Table 6

This table converts the employment by sector into building area and land area needed to support development. The conversion factors for this process vary a great deal from industry to industry. There are no definitive national data for these estimated ratios.

The process of converting employment to building area demand and land area demand will benefit from the use of local data. However this information can be difficult to obtain locally. If there is a local GIS system that has building size data by parcel, and parcel data, the MPO could geocode firm-level employment data from the ES 202 file in order to obtain local building and land demand ratios. Time series employment data and building areas would allow the tracking of these demand ratios over time and could show long term change in the demand for land and building space by industry group. The other approach that could be used is a survey of existing employers. The main drawback to the survey approach is the fact that the data is only good for one point in time.

The data on floor area ratios, space per employee, and average building size, in the sample model application are taken from a study done by Rutgers University - Burchell (1997a), Burchell (1993).

Vacancy rates were not used in the model. They will increase the amount of building space demand and the amount of land consumed. This should be done during any local elaboration of the SCALDS Model. The floor area ratios (FAR) used in the model were estimated using comparable land use types from Metro (1997a). All other number in this table were calculated based on the ratios and the data in Table 5.

Water and Sewer Costs – Table 7

This table estimates the demand for water and sewer service and the cost of water, sewer and storm water services for the urban area. A number of the issues related to infrastructure cost and availability were previously discussed during the discussion on Table 4.

NOTE: Water and sewer demand calculations need to be reviewed for very low density and low density residential. These residential areas may not be served by public water and/or sewer systems in the MPO area.

Non-residential water and sewer demand do not include water and sewer demands for industrial processes and as such these estimates are lower than the expected demand from non-residential uses. The industrial process demand for water and sewer services varies greatly for non residential uses such as food processing, micro processor manufacturing, restaurants, hotels, offices etc.

The water and sewer demand factors are based on standard engineering assumptions for water and sewer system planning. The water gallons per person per day function was taken from Burchell (1997a), page IV – 30, Rainier (1990) and Borlan (1983). The sewer gallons per person per day function was taken from Burchell (1997a), page IV – 30 and Burchell, 1(992a).

The cost of water and sewer service in the sample model application was based on average billing for water and sewer consumption on a dwelling unit equivalence basis for the City of Portland Oregon. The Storm Water Fee is based on the City of Beaverton, Oregon annual fee per Dwelling Unit equivalent of storm water run off. Local average costs should be substituted for these costs in order to make these estimates applicable to a particular metropolitan area.

Land Consumption by Type – Table 8

This table marks the end of the physical development path in the SCALDS Model. From here the Model is linked to Summary Tables 17 and 18. It begins the travel cost path in Table 9.

Land consumption forecasts are based on the data in two tables, Table 3 (Housing Mix) and Table 6 (Non-Residential Development Mix). The calculation of residential land consumption is very simple. The number of units is multiplied by the density of units per acre to estimate the residential land consumption. Table 6 contains a calculation of the number of employees per gross acre. The demand for non-residential land is estimated by dividing the total employment by the number of employees per acre.

Acres are gross acres that include the area for any public rights of way. If a metropolitan area wishes to change the land area basis to net acres (acres less public rights of way) it will be necessary to recalculate the density factors used in the Model.

The one type of land use which is not estimated directly by this model is public land. These lands include schools, parks, public buildings and public open spaces. A place holder number has been put into the model for this type of land use. Private non-profit uses such as churches, private schools, fraternal and civic organizations are not explicitly addressed by the model. They are assumed to be in the non-residential land uses based on the employment, but the Model probably underestimates them. The MPO should develop an estimate of the amount of land consumed by public uses and put it into the Model under the other land category. This process could also include the estimation of the amount of private nonprofit lands consumed in the urban area.

Travel Data – Person Miles of Travel - Table 9

This table is the beginning of the travel cost path in the SCALDS Model and is linked back to Table 2 in order to estimate the total number of person trips at the regional level.

The total number of person trips is derived from the total number of households and the average number of trips per household. Total number of trips are allocated to individual modes based on the percentage of trips made by vehicle type. Total daily person miles traveled is then calculated by multiplying the total number of trips by their average trip length. Finally, annual personal miles traveled are estimated by multiplying the daily total by 330. The result is a calculated annual and daily estimate of person or passenger miles traveled by mode.

The National Personal Transportation Survey (1990) data is a default value that can be used to make most of these calculations. The 1995 survey data just became available and a MPO should probably substitute the 1995 values for the 1990 if they to do not wish to use local numbers. National data sources used in this report include the following: Vincent (1994) and Gross (1997).

An MPO with an up-to-date travel forecasting model or local travel data will use these local data instead of nationally estimated values. Model runs can produce better estimates of differences in trip lengths and mode shares for alternative land development scenarios. The MPO may wish to use locally derived per-capita and/or per-household trip estimates and local mode split data to derive the data in these tables. The data in the sample model application is from Portland's Metro and was derived from the following report: Metro (1997a).

Travel Cost (Non Peak) - Table 10[18]
Travel Cost (Peak) - Table 11
Total Travel Cost - Table 12

[18] MPOs using the prototype model should consider the appropriateness of these costs for their environment. It is our intent to extend this model in future work to provide a mechanism to calculate local travel costs based in part on the data from local travel demand models.

These three tables are the heart of the travel cost-estimating path in the SCALDS Model. Tables 10 and 11 contain the estimate of the cost per passenger mile for peak and off-peak travel by all modes except truck. (Truck costs are assumed to be the same as bus cost for this initial analysis). Table 12 is the table in which the number of miles traveled and the cost per mile are combined to produce a total travel cost estimate.

Table 10 and 11 contain the cost estimates that were developed for the City of Boulder Colorado by Parsons Brinckerhoff in the report; Parsons Brinckerhoff Quade & Douglas Inc. (1996e). The methodology used in this section of the SCALDS Model is based on the methodology developed by Apogee Research Inc. (1994). The discussion in this section will focus on the details of the calculated travel cost estimates.

Four of the cost variables were not calculated directly. The values for Noise Pollution, Water Pollution, Waste, and Barrier Effects were taken from the Litman (1995).

Bus costs are used as a surrogate for truck cost in this version of the Model, because no truck cost models have been developed at this point in time. This work needs to be undertaken for a future version of this model.

The data used to estimate the cost of transportation is not generally available at the MPO level. MPO's do not need to maintain these data but do need to know where to look for updates of national cost numbers. MPO's do need to maintain information on basic transportation measures such as annual average vehicle miles traveled and average vehicle occupancy at the regional level if they wish to use numbers that reflect local trends rather than national trends.

Depreciation and Financing Costs

Vehicle depreciation was estimated using the following equations.

$$\text{SOV \& HOV Costs} = \frac{\left(\dfrac{(\text{Annual Finance Cost} + \text{Annual Depreciation Cost})}{\text{Average Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

$$\text{Bicycle Cost} = \frac{\left(\dfrac{(\text{Purchase Cost} - \text{Resale Value})}{\text{Vehicle Life}}\right)}{\text{Average Annual VMT}}$$

$$\text{Pedistrian Cost} = \frac{\text{Average Shoe Cost}}{\text{Average Shoe Life in Miles}}$$

The values used in the SCALDS Model are derived from the report by Parsons Brinckerhoff Quade & Douglas, Inc., <u>Cost of Travel in Boulder</u>, (1996e). The data used in this report came from the following sources: American Automobile Association (AAA), (1995). Bicycle and shoe costs were estimated from local data sources. The cost estimates would be improved by the development of depreciation estimates for trucks and buses.

Vehicle Insurance Cost

Insurance cost estimates were developed for single occupancy vehicles and high occupancy vehicles in the Boulder model. No insurance costs were estimated for bicycle and pedestrian travel because this type of insurance is generally not available. Insurance costs for truck and buses were not estimated.

$$\text{SOV \& HOV Costs} = \frac{\left(\dfrac{\text{Annual Insurance Cost}}{\text{Average Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

The data used in the SCALDS Model was taken from the report Cost of Travel in Boulder (ibid). The cost estimates in this report were derived from the American Automobile Association (AAA), Your Driving Costs, 1995 Edition, and local transportation planning data.

Registration and Licensing[19]

Registration and licensing costs are expected to vary on a state by state basis. The estimated cost for this report is for cars in Colorado. Each MPO needs to determine the registration and licensing cost for its own state. Truck and bus registration and licensing costs should also be estimated and added to the Model. These fees are more complex than auto registration fees and will require more knowledge of the composition of the local truck and bus fleet and their registration costs.

$$\text{SOV \& HOV Costs} = \frac{\left(\dfrac{\text{Annual Registration Fees}}{\text{Average Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

$$\text{Bicycle Cost} = \frac{\text{Annual Registration Fee}}{\text{Average Annual VMT}}$$

The data used in the SCALDS Model were taken from Cost of Travel in Boulder (ibid). The data used to estimate these costs were derived from the following sources: FHWA, Highway Taxes and Fees, Bikes National Bike Registry.

Gasoline Cost

Gasoline costs are among the most visible of the costs paid by the drivers of cars. In addition, these cost can and do change frequently during the course of a year. Differences in fuel economy can produce substantial variation in the cost of fuel consumed by an individual. The gasoline costs used in the model were derived from national average costs in order to represent an overall average. If local gasoline prices are consistently higher or

[19] Registration fees included in the cost factor are the portion of fees not used to fund construction or maintenance projects.

lower than the national average cost for gasoline, the MPO may wish to adjust this cost estimate.

$$\text{SOV \& HOV Costs} = \frac{\left(\left(\frac{1}{\text{Fuel Economy MPG}}\right) * \text{Fuel Cost per Gallon}\right)}{\text{Vehicle Occupancy}}$$

The data used in the SCALDS Model was taken from Cost of Travel in Boulder (ibid). Average gasoline consumption was derived from - Fleet Fuel Consumption Look Up Table, Denver Regional Council of Governments, while average fuel cost per gallon was taken from Gross (1995).

Maintenance Cost

Vehicle maintenance costs are subject to considerable variation in a metropolitan area. Some of this variance is the result of personal preferences and some of it is the result of the characteristics of the vehicles in the urban area. Accordingly, national cost estimates were used for this variable. Truck and bus maintenance costs were not estimated or included in the Model.

$$\text{SOV \& HOV Costs} = \frac{\left(\frac{\text{Annual Maintenance Costs}}{\text{Average Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

$$\text{Bicycle Cost} = \frac{\text{Annual Maintenance Cost}}{\text{Average Annual VMT}}$$

The data used in the SCALDS Model was taken from Cost of Travel in Boulder (ibid). The source of the data was American Automobile Association (1995). Bicycle costs were estimated from local data sources.

Transit Fares

Transit fares are set by local governing bodies and are normally set at a level that is intended to provide the transit provider with a percentage of the total transit operating budget. The amount of the transit system budget that is collected from the fare box varies substantially from urban area to urban area. This cost should be revised by the MPO to account for local conditions. The local transit agency should be able to provide the other necessary data needed to estimate this cost.

$$\text{Transit Fare} = \frac{\text{Total Annual Fares}}{\text{Total Annual Passenger Miles}}$$

The data used in the SCALDS Model was taken from Cost of Travel in Boulder (ibid). Transit Fares may also be estimated from Federal Transit Administration (1994).

Residential Parking Cost[20]

The estimation of residential parking cost will require the collection of a large amount of local data. These data also are sensitive to fluctuations in the type and amount of local development and local cost variations. Several alternative cost estimation methodologies are possible. A more complex formulation of this methodology would estimate these costs using an arithmetic moving average of costs to allow for year to year variations. However, all of the alternative methodologies substantially increase the complexity of the cost estimation process with no assurances of a better estimate of the costs. MPOs will need to work with city and county building departments and with county assessors to estimate this cost locally.

$$\text{SOV \& HOV Costs} = \frac{\left(\dfrac{\left(\left(\begin{matrix}\text{Number}\\ \text{Garages}\\ \text{Constructed}\end{matrix}\right) * \left(\left(\begin{matrix}\text{Land}\\ \text{Value}\end{matrix}\right) + \left(\begin{matrix}\text{Construction}\\ \text{Cost}\end{matrix}\right)\right)\right) * \left(\left(\begin{matrix}\text{Number}\\ \text{Surface}\\ \text{Parking}\\ \text{Spaces}\end{matrix}\right) * \left(\left(\begin{matrix}\text{Land}\\ \text{Value}\end{matrix}\right) + \left(\begin{matrix}\text{Construction}\\ \text{Cost}\end{matrix}\right)\right)\right)}{\text{Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

The data used in the SCALDS Model was taken from <u>Cost of Travel in Boulder</u> (ibid). Residential parking costs were derived from the report by Apogee Research (1994) and modified with local costs for new garage construction and open parking spaces,

Non-Residential Parking Cost User Paid

Non-residential parking costs that are paid by the user are out-of-pocket costs. These costs are normally paid by users that park in a small portion of an urban area. Parking costs are most common in central business districts. There are no good national sources for these data. The data must be developed locally. There will be variations in the cost of on-street paid parking and off-street paid parking depending on variations in public policy and local market conditions. An MPO will need to develop a methodology for collecting and maintaining these data. The cost estimated by the following equation will produce a regional average cost. This will however understate the cost for those individuals actually paying for parking and overstate the cost for those individuals who never pay for parking.

---

[20] Parking costs are derived for Boulder Colorado using local data. Future extensions of the prototype model will provide a method for calculating these costs directly. This may result in the creation of a single parking cost category to replace the three cost categories presently used in the prototype model. Users of the model should carefully evaluate the parking cost estimates produced by different land use scenarios.

$$\text{SOV \& HOV Costs} = \frac{\left(\dfrac{\text{Annual User Parking Cost}}{\text{Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

The data used in the SCALDS Model was taken from <u>Cost of Travel in Boulder</u> (ibid).

Non-Residential Parking Cost – Societal Costs

This cost includes the cost of all of the non-residential "free" off street parking spaces in an urban area. This cost estimate adds the average cost paid by business and industry to provide free parking to their customers and employees. The methodology used in this calculation might be improved through the use of an arithmetic moving average, but this type of a process would require substantially more data collection and maintenance.

$$\text{SOV \& HOV Costs} = \frac{\left(\dfrac{\left(\begin{pmatrix}\text{New Non}\\ \text{Residential}\\ \text{Spaces}\\ \text{Constructed}\end{pmatrix} * \left(\begin{pmatrix}\text{Land}\\ \text{Value}\end{pmatrix} + \begin{pmatrix}\text{Construction}\\ \text{Cost}\end{pmatrix}\right)\right) + \left(\begin{pmatrix}\text{Number}\\ \text{Existing}\\ \text{Non}\\ \text{Residential}\\ \text{Parking}\\ \text{Spaces}\end{pmatrix} * \begin{pmatrix}\text{Annual}\\ \text{Maintenance}\\ \text{Costs}\end{pmatrix}\right)}{\text{Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

The data used in the SCALDS Model was taken from <u>Cost of Travel in Boulder</u> (ibid). The data on "non-residential parking costs – societal costs" was derived from the report by Apogee Research (1994), and was modified with local data.

Accident Costs – Not Covered by Insurance

Estimating accident cost from local data is a difficult process at best. Our SCALDS Model uses national data to estimate these costs and MPO's should consider sticking with the national and state level data when estimating these costs.

$$\text{All Modes} = \left(\left(\left(\begin{pmatrix} \text{Fatal} \\ \text{Accident} \\ \text{Rate} \end{pmatrix} * \text{PMT} \right) * \begin{pmatrix} \text{Fatal} \\ \text{Accident} \\ \text{Cost} \end{pmatrix} \right) + \left(\left(\begin{pmatrix} \text{Injury} \\ \text{Accident} \\ \text{Rate} \end{pmatrix} * \text{PMT} \right) * \begin{pmatrix} \text{Injury} \\ \text{Accident} \\ \text{Cost} \end{pmatrix} \right) + \left(\left(\begin{pmatrix} \text{Property} \\ \text{Damage} \\ \text{Only} \\ \text{Accident} \\ \text{Rate} \end{pmatrix} * \text{PMT} \right) * \begin{pmatrix} \text{Property} \\ \text{Damage} \\ \text{Only} \\ \text{Accident} \\ \text{Cost} \end{pmatrix} \right) \right) * \begin{pmatrix} \text{Share} \\ \text{of} \\ \text{Accident} \\ \text{Cost} \\ \text{Burden} \end{pmatrix}$$

The data used in the SCALDS Model was taken from Cost of Travel in Boulder (ibid). The accident cost estimates were based on the following sources: Accident Rates – Colorado Department of Transportation; Cost per accident – National Safety Council.

Travel Time

The key element in estimating the cost of travel is determining the value of time. This cost is normally assumed to be a percentage of the average wage in an urban area. If local data is not available, the US Bureau of Labor Statistics has an average for most urban areas. Average costs are calculated for each mode using the mode's individual travel speed and the value of time.

$$\text{All Mode Costs} = \left(\frac{1}{\text{Speed MPH}} \right) * \text{Value of Time}$$

The data used in the SCALDS Model was taken from Cost of Travel in Boulder (ibid). The value of travel time is based on 50 percent of the average wage, as reported in the 1993 Boulder County Almanac.

Federal/State Highway Investment

Federal and state capital cost and operating expenditures per VMT are estimated at the state level due to limitations of the available data. In our model the amount of state and federal gas taxes is deducted from the total expenditures because gas taxes are included in the model under the section on gasoline costs. This deduction removes a potential double counting of costs.

Cost factors are used for each mode to reflect the magnitude of the damage done to the transportation infrastructure by each of the travel modes. The result is a weighted estimate of the highway operating and capital cost by mode.

The data used in our SCALDS Model sample application was taken from Cost of Travel in Boulder (ibid). Federal and State highway investment and operating costs were derived from FHWA (1995a).

In the Boulder study local capital and operating costs were estimated in the same manner. However local capital costs have already been estimated along with other local infrastructure costs, so this local cost estimate was removed from this table to avoid double counting. This may slightly underestimate local operating expenses for roads. This is an issue that deserves some additional study in a second phase of the model development process.

$$\text{All Mode Cost} = \frac{\left(\left(\frac{\text{Fed State Capital Costs}}{\text{VMT}}\right) * \left(\text{Vehicle Cost Factor}\right)\right) + \left(\left(\frac{\text{Fed State Operating Costs}}{\text{VMT}}\right) * \left(\text{Vehicle Cost Factor}\right)\right) - \left(\text{Federal State Gas Tax}\right)}{\text{Vehicle Occupancy}}$$

The vehicle cost factors used in this process, representing the relative damage caused by individual vehicle by mode, are as follows:

Mode	Capital Expenditures	Maintenance
SOV/HOV	0.683	0.719
Transit Bus	1.810	3.420
Bicycle	0.034	0.014

Municipal Services

There are a few municipal development costs that have not already be accounted for directly or indirectly in previous tables. Public safety is one of these costs. In Boulder, the portion of the public safety budget that was directly related to traffic and travel was estimated using the following equation.

$$\text{SOV \& HOV Costs} = \frac{\left(\frac{\left(\text{Annual Police Budget}\right) * \left(\text{\% Trans Calls}\right)}{\text{Annual VMT}}\right) + \left(\frac{\left(\text{Annual EMS Budget}\right) * \left(\text{\% Trans Calls}\right)}{\text{Annual VMT}}\right) + \left(\frac{\left(\text{Annual Court Budget}\right) * \left(\text{\% Trans Cases}\right)}{\text{Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

MPO's will need to work with local governments to obtain the cost estimates included in this equation. Once a budget allocation process has been developed, it should be relatively easy for the MPO update this information as needed. Additional research into local, state and federal expenditures should be undertake to insure that all of the appropriate governmental costs have been include in this model.

The data used in the SCALDS Model was taken from Cost of Travel in Boulder (ibid). Municipal service costs were estimated by the City of Boulder and Parsons Brinckerhoff Quade & Douglas, Inc. based on information obtained from the Boulder Fire, Police and Municipal Court Departments and their budgets.

Government Net Transit Costs (Total Cost – Fare Box Revenues)

This cost variable was developed to estimate the transit costs that are not paid for by transit fares. The methodology for estimating this cost is relatively simple. However, depending on the source of the revenue that supports these operational costs, additional analysis may be required to insure that no double counting of cost has occurred.

The estimation of this operational cost leaves only one transit cost that may not have been included in the SCALDS Model - transit capital cost. Transit capital cost can vary greatly from year to year and the normal problems related to the timing of construction. These capital costs are a candidate for the use of an arithmetic moving average methodology or some other methodology that explicitly works with variations in expenditures / cost over time.

$$\text{Net Transit Cost} = \left(\frac{\left(\begin{pmatrix} \text{Total} \\ \text{Transit} \\ \text{Costs} \end{pmatrix} - \begin{pmatrix} \text{Transit} \\ \text{Fares} \end{pmatrix} \right)}{\begin{matrix} \text{Annual} \\ \text{Transit} \\ \text{Passenger} \\ \text{Miles} \end{matrix}} \right) * \begin{pmatrix} \text{Peak} \\ \text{NonPeak} \\ \text{Adjustment} \\ \text{Factor} \end{pmatrix}$$

The data used in the SCALDS Model was taken from <u>Cost of Travel in Boulder</u> (ibid). These costs are based on data obtained from the Federal Transit Administration (1994).

Deferred Investment[21]

This estimated cost is an attempt to capture an often hidden cost associated with development. State and local infrastructure construction often does not keep up with growth. It is not uncommon in an urban area to find places where development has occurred and existing infrastructure is not maintained to standards, due to the demands placed on state and local governments to expend facilities rather than facilities maintenance. Most urban areas have an estimate of the order of magnitude of this deferred maintenance cost.

The identified unfunded need for capital investment is identified from the CIP and it is allocated over the number of years that it is expected to remain unfunded. A cost allocation factor is used to allocate the unfunded need to individual modes. The data to do these estimations are normally available from local governments and normally include estimates of the number of years that maintenance is expected to remain unfunded given the current level of available resources. A cost allocation factor is used to allocate the unfunded need to individual modes. This methodology provides a minimum estimate of the deferred cost. It does not attempt to do an independent estimation of the needs of the

[21] The authors recommend that the MPO estimate the deferred maintenance cost of the existing road system and substitute this cost for the 1 and 2 cents per passenger mile included in the model to avoid any double counting of costs. This estimate should not include capital costs of projects, since cost of delay associated with congestion are already included in Tables 10 and 11.

region. MPOs should estimate this cost for the local urban area when implementing the SCALDS Model.

$$\text{Total Vehicle Cost} = \frac{\left(\left(\frac{\left(\frac{\text{Local Unfunded Maintenance Need}}{\text{Years of Need}}\right)}{\text{Local Annual VMT}}\right) + \left(\frac{\left(\frac{\text{State Unfunded Maintenance Need}}{\text{Years of Need}}\right)}{\text{State Annual VMT}}\right)\right) * \left(\text{Cost Allocation Factor}\right)}{\text{Average Vehicle Occupancy}}$$

$$\text{Pedestrian Cost} = \frac{\left(\frac{\text{Unfunded Need}}{\text{Years of Need}}\right)}{\text{Pedestrian VMT}}$$

The data used in the SCALDS Model was taken from Cost of Travel in Boulder (ibid). The data used to estimate these costs was derived from the Transportation Master Plan, Update for Boulder Valley and the Colorado Department of Transportation capital improvement plan.

Air Pollution Cost

Air pollution costs are one of several transportation externalities that have been studied extensively during the last two decades. Substantial data on the cost of air and other forms of pollution can be obtained from separate work recently completed by Litman (1995) and Mark Delucchi (1996) on the social costs of transportation. The methodology used in the SCALDS Model is expressed in the following equation.

$$\text{Vehicle Cost} = \frac{(\text{Emissions Per Vehicle Mile} * \text{Cost of Pollutant Per Gram})}{\text{Vehicle Occupancy}}$$

A metropolitan area can use a different formulation of this equation but it will still need to rely on the various national estimates of the external cost of pollution in order to calculate the costs. The data used in the SCALDS Model was taken from Cost of Travel in Boulder (ibid). Data on Air Pollution costs were derived from Apogee Research (1994).

Travel Energy Consumption – Table 13

The cost of energy is included in the estimates of peak and non-peak travel cost in Tables 10 and 11. The non-dollar-denominated estimates of energy consumed directly by transportation are estimated in this table. The energy consumption data is derived from the information in National Transportation Statistics, 1996, Tables 105, 106, and 107. The total annual energy usage is calculated in a straightforward manner using the estimated total passenger miles by vehicle type as derived in Table 9. Estimated energy consumption can be converted into gallons of fuel consumed by using the factor in the table if a metropolitan area needs this information.

The total energy consumption is calculated in this table; it accounts for approximately 7 percent of total travel cost excluding the value of time. However, while the total energy consumption is calculated here for illustrative purposes, they are not passed on to the cost summary in Table 17 in order to avoid double counting of costs.

The data necessary to create this table come from national sources. There is no easy method that could be employed by a metropolitan area to collect these data locally. The best path for the maintenance and collection of these data is the collection of the reports that provide it. The best source for these data is the report produced by Volpe National Transportation Systems Center (Cambridge) for Bureau of Transportation Statistics, National Transportation Statistics 1996, Washington D.C. (1997).

Energy Cost and Consumption – Table 14

Table 14 estimates the cost of energy and the amount of energy consumed by urban land uses. The energy consumption estimates include all the energy consumed by all land uses in an urban area. These estimates do not include any industrial process energy used by large energy consumptive industries such as aluminum smelters.

The energy consumption estimates in this table are derived from the "Place^{3}s" approach of the US Department of Energy. The energy consumption numbers are derived by modifying the values presented in the report, The Energy Yardstick, Allen (1996). The energy consumption values in the DOE report were modified to remove energy consumption associated with transportation. The result is an approximation of the energy consumed by various residential land use types.

The Place^{3}s energy consumption methodology is a first generation effort. It is probable a more complete integration of the Place^{3}s methodology and the SCALDS Model could be accomplished after some additional study of the operational details of the two models.

It is possible for a metropolitan area to use the Place^{3}s model to develop estimates of energy consumption at a regional level. These estimates can be maintained over time and entered into the SCALDS Model exogenously. Cost estimates can be converted to the base year for the SCALDS Model using the CPI factors.

The Place^{3}s data was derived from the report by Allen, Elliot, Michael McKeever and Jeff Mithcum, (1996) The Energy Yardstick: Using Place^{3}s to Create More Sustainable Communities, DE-FG49-94R900027, Salem, Oregon, Oregon Department of Energy.

Air Pollution Per Passenger Mile - Table 15[22]

The cost of air pollution is included in the estimates of peak and non-peak travel cost in Tables 10 and 11. The non-dollar cost estimates of air pollution produced directly by transportation is estimated in this table. The pollution estimates are denoted in tons of pollutant per year.

There are other models that can be used by a metropolitan area to estimate the amount of air pollution produced by traffic in an urban area outside the SCALDS Model framework. If the MPO wishes to use one of these models, the resulting estimates can be entered into the SCALDS Model exogenously. The alternative is to use the average air pollution per passenger mile figures from this table to estimate the total level of air pollution.

A review of the literature on air pollution rates by vehicle type was conducted and it did not locate a US based study that estimated the amount of air pollution produced by vehicle type as measured in amounts per passenger mile. Therefore to allow the SCALDS Model to complete the non cost estimates, a comparable non US based study was used. The air pollution rates by vehicle type used in Table 15 are derived from Greater Vancouver Regional District Air Quality Management Plan: State 2 Draft Report Priority Emission Reduction Measures, May 1992, Table 5-8, p 5-43, as cited in Litman (1995), page 3.10-5 (Table 3.10-5 Emission Rates for Selected Modes grams per passenger mile).

Schools Costs and Projection – Table 16

Table 16 is included in the SCALDS Model as a placeholder. At this point in time, the cost estimates and estimates of the number of new students produced in this table is not connected to the cost and non cost summaries in Table 17 and 18. Table 16 estimates average number of new pupils and average education costs.

NOTE: This type of estimate performs well only for short term, local projections of growth because it is based on two assumptions. First, the demographics of an urban area will not change very much in the short term (less than 5 years). Second, the number of students that will be generated from a particular type of housing unit will be the same as recently generated from existing housing units of the same type.

Over time it is necessary to use a different model - cohort survival - to estimate the number of school children at a regional level. This model takes into account changes in the

[22] The air pollution production rates used in this table are taken from a study by the Greater Vancouver (BC) Regional Council. In subsequent enhancements, we will replace this data with other values.

demographic patterns of the region and provides better long term estimates of the number of students that are expected regionally.

MPO analysts need to take care when using new households to estimate the number of school age children. It is possible for the analyst to make changes in the housing mix that mathematically would appear to change the number of school age children. However this is not the case in reality. The demographics of the region are not changed by changing the housing mix. The analyst should adjust the mix of new housing units within the context of the expected average household size and projected rate of household formation.

The MPO needs to adjust these figures to match local conditions. The cost factors used in this prototype model are the average cost for students in the State of Oregon in 1995. The number of school age children per unit is taken from Burchell (1997a) , page IV – 2, estimated from 1990 US Census PUMS data for new non-central city housing in Michigan. While these numbers are a starting point for the SCALDS Model they cannot be expected to produce good estimates when applied to demographically different situations. A metropolitan area can choose to use projections from a local school district instead of using this type of projection factor, to develop the data exogenously and then enter it into the Model.

One area of further analysis that would improve the operation of this model would be an estimation of the number of school age children by housing unit type by number of bedrooms. These ratios should perform better in the short term than a simple number of students per household. However, to use these data it is necessary to have better data on the composition of the housing stock. These data will require more effort to collect and more effort to maintain. If this type of data is available, the SCALDS Model can be easily be modified to allow the estimations to be made by using these more detailed data.

4.4 SAMPLE MODEL APPLICATION

In the previous section we have explained the elements of our SCALDS Model, their relationships, the sources of data on which they are based and in some cases the limitations of application. In this section and the associated tables we present the results of several sample applications of the SCALDS Model.

Because this model is in the very preliminary stages of development, the results of the simulations presented below are merely illustrations of order of magnitude impact estimates. They indicate the general direction and magnitude of changes that can be expected in various costs, and the distribution of these costs.

Since the sources of data used in this sample application come from a variety of national as well as local sources, they represent in many cases “placeholders” for more accurate parameters, to be furnished by metropolitan area planners.

Summary Tables – Table 17 and 18

Tables 17 and 18 contain the summaries of the cost and non-cost estimates developed in the preceding sixteen tables of the SCALDS Model. These two tables can be used to develop scenario comparisons such as the ones contained in the following examples.

As a test of the sensitivity and operation of the SCALDS Model, Parsons Brinckerhoff developed two scenarios that are, in part, based on projections and assumption contained in the Metro Regional Framework Plan (Metro 1997d). This Plan is scheduled for adoption in December 1997 and as such provides a current set of population, employment and transportation forecasts for use by the SCALDS Model.

The scenarios are intended to be illustrative and not a definitive analysis of the cost of alternative land use patterns in the Portland metropolitan area. The SCALDS Model used to develop these illustrative scenarios was not completely adapted to reflect the conditions in Portland. In addition, Metro's staff has not reviewed the inputs to the model or the results of the model process. Nevertheless, the following two scenarios will illustrate how the SCALDS Model can work.

The two scenarios presented are identified as Metro Regional Plan and Metro Sprawl. The only differences in these two spreadsheets are the number of single family housing units assigned to the Conventional SFD / Small Lot SFD and a small difference in the average trip length for auto trips to reflect the differing densities of the new single family housing areas.

The creation of these scenarios began with two copies of the same set of spreadsheets containing the data for the Metro Regional Plan scenario. The spreadsheet for the Metro Sprawl Scenario was then modified by shifting single family residences from the small lot single family land use type to the conventional single family land use type and by making a small increase in average trip length for the SOV and HOV vehicle types. The scenario costs were then compared and are shown in the Table below.

Total Annual Scenario Cost by Year

Year 1990 Base Year	**Metro Regional Plan**	**Metro Sprawl**	**Difference (Sprawl – Plan)**
1995 5 Model Years	$7,833,550,569	$9,010,519,641	***$1,176,969,073***
2005 15 Model Years	$9,594,617,050	$11,069,634,947	***$1,475,017,897***
2015 25 Model Years	$11,540,873,445	$13,322,601,691	***$1,781,728,246***
Change 1995 to 2015	***$3,707,322,876***	***$4,312,082,050***	

It is apparent that the lower density development pattern has higher operating costs, in excess of $1 Billion per year, after the first five year time period. These cost differences increase to nearly $2 Billion per year by 2015. A more complete comparison of the cost estimates for the scenarios are presented in the following figures, 11 and 12.

4.5 ADAPTING THE PROTOTYPE MODEL FOR YOUR MPO

For this model to be useful to an MPO it must be adapted to reflect the conditions in the local urban area. The process is straightforward to experienced spreadsheet users. The first step is to make a copy of the spreadsheet and enter the basic data needed by the prototype model. These data includes historic and projected values at the MPO level for population, number of households, single family / multifamily household split, total employment, retail / non-retail employment split and projected travel (Table 2). It also includes detailed housing mix (Table 3) and employment at the two digit SIC level (Table 5). When these data is entered, an analyst is ready to begin the cost estimation process.

The next step is to determine the base year for the analysis and to manually adjust all cost variables to the new base year cost. Policy variables that are adjustable in the prototype model are identified by the gray shading in a cell. These cells should be adjusted to reflect the present conditions in the MPO. All other cells are protected and cannot be changed. Constructing scenarios from existing conditions is a matter of making a copy of the existing condition file and then making adjustments to the policy variable cells. By comparing the results of the two spreadsheets, as depicted in Tables 17 and 18, the analyst will be able to examine the relative costs of the two scenarios that have been created.

Figure 11: Summary: Metro Regional Plan Scenario

	A	B	C	D	E
1	**COST SUMMARY**	**Metro Regional Plan Costs**			
2		**1995**	**2005**	**2015**	**Change 95 - 15**
3	Annual Full Cost of Transportation - Without the Value of Time	$ 4,357,448,808	$ 5,373,106,876	$ 6,563,069,023	$ 2,205,620,215
4	Total Annual Private Operating Water Costs	$ 543,776,669	$ 669,106,720	$ 799,205,555	$ 255,428,886
5	Total Annual Private Operating Sewer Costs	$ 551,749,657	$ 679,942,299	$ 813,527,620	$ 261,777,964
6	Total Annual Private Operating Storm Water Fees	$ 55,174,766	$ 67,994,029	$ 81,352,561	$ 26,177,794
7	Annual Non-Transportation Operational Energy Cost	$ 2,325,400,669	$ 2,804,467,127	$ 3,283,718,686	$ 958,318,018
8	Estimated Annual Operating Costs Regional Plan	$ 7,833,550,569	$ 9,594,617,050	$ 11,540,873,445	$ 3,707,322,876
9					
10	**NON COST SUMMARY**				
11		**1995**	**2005**	**2015**	**Change 95 - 15**
12	Population	1,596,100	1,920,264	2,205,800	609,700
13	Households	627,937	774,300	917,000	289,063
14	Housing Units	642,380	792,109	938,091	295,711
15	Total Employment	988,915	1,228,500	1,486,600	497,685
16	Total Developed Urban Land in Acres	1995	2005	2015	Change 95 - 15
17		299,842	340,398	382,841	82,999
18	Water Demand - Gallons Day	1995	2005	2015	Change 95 - 15
19		129,470,160	159,310,646	190,286,557	60,816,397
20	Sewer Demand - Gallons per Day	1995	2005	2015	Change 95 - 15
21		99,621,106	122,766,997	146,886,568	47,265,462
22					

Figure 12: Summary: Metro Sprawl Scenario

	A	B	C	D	E
1	**COST SUMMARY**	**Metro Sprawl Cost**			
2		**1995**	**2005**	**2015**	**Change 95 - 15**
3	Annual Full Cost of Transportation - Without the Value of Time	$ 5,520,271,497	$ 6,806,966,654	$ 8,272,657,946	$ 2,752,386,449
4	Total Annual Private Operating Water Costs	$ 543,776,669	$ 669,106,720	$ 799,205,555	$ 255,428,886
5	Total Annual Private Operating Sewer Costs	$ 551,749,657	$ 679,942,299	$ 813,527,620	$ 261,777,964
6	Total Annual Private Operating Storm Water Fees	$ 55,174,766	$ 67,994,029	$ 81,352,561	$ 26,177,794
7	Annual Non-Transportation Operational Energy Cost	$ 2,339,547,053	$ 2,845,625,245	$ 3,355,858,010	$ 1,016,310,957
8	Estimated Annual Operating Costs Regional Plan	$ 9,010,519,641	$ 11,069,634,947	$ 13,322,601,691	$ 4,312,082,050
9					
10	**NON COST SUMMARY**				
11		**1995**	**2005**	**2015**	**Change 95 - 15**
12	Population	1,596,100	1,920,264	2,205,800	609,700
13	Households	627,937	774,300	917,000	289,063
14	Housing Units	642,380	792,109	938,091	295,711
15	Total Employment	988,915	1,228,500	1,486,600	497,685
16	Total Developed Urban Land in Acres	1995	2005	2015	Change 95 - 15
17		307,779	361,789	419,091	111,312
18	Water Demand - Gallons / Day	1995	2005	2015	Change 95 - 15
19		129,470,160	159,310,646	190,286,557	60,816,397
20	Sewer Demand - Gallons per Day	1995	2005	2015	Change 95 - 15
21		99,621,106	122,766,997	146,886,568	47,265,462

5.0 RECOMMENDATIONS FOR FUTURE RESEARCH

The nested set of relationships diagrammed in our Chapter 3 framework necessarily encompass a very wide set of behaviors by all sectors of our society and economy, going well beyond the traditional concerns of transportation researchers. In fact, from the perspective of transportation researchers, the most challenging questions are outside of the field of transportation. This is in part because our knowledge of these other fields is relatively limited. It is also because we are aware of many important research efforts ongoing within the field of transportation that relate to the topic of this report, but we understand less well comparable leading edge research in other disciplines.

Nevertheless from our perspective there are several aspects of transportation research which need to be addressed in order to fill in gaps in our knowledge of the impacts of alternative development patterns. We will identify these first, before listing a series of non-transportation topics where we also feel that research resources would be well spent.

5.1 TRANSPORTATION RESEARCH NEEDS

Among the many transportation topics which we might cite here, the following seem especially significant.

Travel Choices/Travel Behavior

Much of what is known about the interactive influence of transportation and land use in particular, and about travel behavior in general, comes from cross-sectional data sets from metropolitan area travel surveys. There are very few on-going panel surveys, and there need to be many more. This longitudinal research technique makes it possible to answer some questions which recur in discussions about the impacts of alternative development patterns, such as, how do people’s travel choices change when a family changes a residential location, holding all else constant? How do people’s travel choices change with age and income? How do changes of household location relate to changes in employment? Answers to these and related questions typically are inferred rather than observed directly from behavioral data. Panel surveys offer researchers opportunities to untangle complex cause and effect relationships.

Value of Time

This concept continues to be one of the most difficult for decision makers to grasp and apply in the context of benefit cost analysis for transportation investments. The lack of information is particularly noteworthy for the use of non-motorized modes. For example, people frequently assert that those who chose to walk or ride a bicycle see the time spent not in terms of costs but in terms of benefits. If this were literally true then the value of their time would be negative. Should the value of a time spent walking be the same as that of time spent driving? More generally, how does the value of time vary by trip purpose? Since much of the research points to the value of time as being the single largest cost in the full-cost planning framework, more clarity about accounting for time is essential to improve the usefulness of the full-cost frameworks for decision makers.

Transportation Costs for Commercial Vehicles

Several issues surface here. First, the growing practice of using "passenger vehicles" for business and commercial trips substantially complicates the application of a full-cost framework.[23] A careful accounting of commercial trip making in general is required to improve travel model forecasting techniques and prospects for understanding the broader set of costs and benefits of transportation improvements to various sectors of the economy.

Secondly, the ways in which commercial travelers react to congestion needs to be better understoood. It is constantly asserted that congestion "imposes" costs on businesses. Yet anecdotal evidence continues to suggest that businesses adapt more than households do, shifting the time of day of their deliveries and relocating to optimize their travel costs. Previous NCHRP research on the "Costs of Congestion in Metropolitan Areas" was inconclusive. It proved impossible to document the additional costs which had been asserted to accrue to businesses as a result of operating in congested locations, in large part because the businesses themselves had no hard evidence that would permit the calculation of these additional costs.

If the marginal costs to business of operating in congested urban environments cannot be measured, is it fair to assert that they exist? If they don't exist, or at least are smaller than some assert, does this change the overall relationship of costs and benefits between compact urban form and "sprawl?"

Travel Demand Forecasting

The limitations of conventional 4-step travel demand models have been widely documented. In the context of our full-cost framework it is necessary to ask whether the tendency of travel models to forecast rapid growth in vehicle hours of travel per capita is reasonable. As stated above, with the value of travel time weighing heavily among costs of alternative development patterns, the importance of accurate forecasts of vehicle hours of travel is clear. By contrast, if households travel budgets remain constant over time, on average, as some researchers assert, how can this be reconciled with the VMT forecasts of regional travel models used by MPOs?

5.2 LAND USE RESEARCH

Relationship Between Housing Stock, Tenure and Lifestyle

It is necessary to assume that the characteristics of metropolitan area housing stock will not influence the overall demographic trends in a region over time. Yet, advocates of compact urban form and affordable housing are advocating reductions in the size of buildings and building lots through the application of such public policy tools as maximum lot sizes. Are such changes simply a matter of "educating consumers?" Will they result in lower housing costs, thus significantly affecting the full costs of a particular development pattern? Or, in the aggregate will such levels of change in housing infrastructure affect the age from the income and other characteristics of metropolitan areas, if implemented systematically and consistently over time?

---

[23] As does the practice of using light trucks for non-commercial travel.

Redevelopment and Infill

Advocates of compact urban form argue that in a full-cost framework, the reuse and filling in of urban development is the most efficient solution for society. Others argue that redevelopment and infill entails significant costs to both the public sector and the private sector and thus, ultimately, to households as consumers. Under what circumstances do real estate markets support infill and redevelopment? For what types of uses? What is the full set of costs associated with these kinds of development as compared to development at the urban edge?

5.3 OTHER INFRASTRUCTURE COSTS

Water and Sewer

A review of the behavioral assumptions behind many water system plans suggests that the impacts of urban form on water consumption are not consistently applied. Many regional, municipal and private systems are traditionally engineered based on simple standards (such as a number of single family verses multi-family homes likely to occur), and the application of very crude factors to account for non-residential water consumption. While this is certainly due in part to the substantial uncertainties and variations associated with water consumption in both the residential and commercial sectors, it also suggests that the benefits, if any, from smaller lawns, from water recycling systems and other technologies which result in less consumption of water resources may not be adequately incorporated and accounted for in the cost analyses associated with the system plans. For example, if more compact urban form reduces the amount of water required for residential lawns, are there systematic savings which are being ignored?

Energy

Preliminary work by the Allen, et al. (1996) on energy consumption illustrates the opportunity for integrating energy planning into the full-cost framework for metropolitan planning and development. It illustrates an opportunity to integrate more fully various urban systems models research which may be ongoing in different federal agencies. Much of this research relates to growing interest in “sustainable communities.” There is an opportunity to convene forums in which communication can occur across agencies working in this general area of policy interest.

5.4 CONCLUSIONS

The above list is only a sample of the topics which emerge from our attempt to account for the full costs of alternative development patterns. It would be possible to identify needs for research into the capital and operating costs of other utilities, for example; or, into the operations of urban real estate markets and the extent to which their prices capture the full costs of individual properties, land and neighborhoods; or, whether and how underinvestment in infrastructure generates costs for future users in future generations.

We have generated a brief list of topics which illustrate the many opportunities for research which will advance the state of knowledge and practice in the application of full-cost models to regional planning and decision making. Within the field of transportation policy and planning, and the closely related field of land use and urban form, we believe the topics listed above are good places to start.

APPENDIX A

DETAILED EXPLANATION OF MODEL STRUCTURE

The purpose of this Appendix is to furnish the reader with the information required in order to understand the detailed workings of the SCALDS Model. The Appendix B contains a complete set of each of the tables as diagrammed in Table 19. A copy of Table 19 is reproduced in this Appendix for use and reference.

The text which follows under the title of each table, below, leads the reader to refer to specific cells, rows and columns in the table themselves. The text contains definitions of these cells and formulas which we apply there. It also indicates whether the particular variable is internal or external to the SCALDS Model.

The attached tables are in the same form as they appear in the electronic version of the model, of which a copy is attached.

TABLE 1 - CPI – All Urban Consumers – All Goods

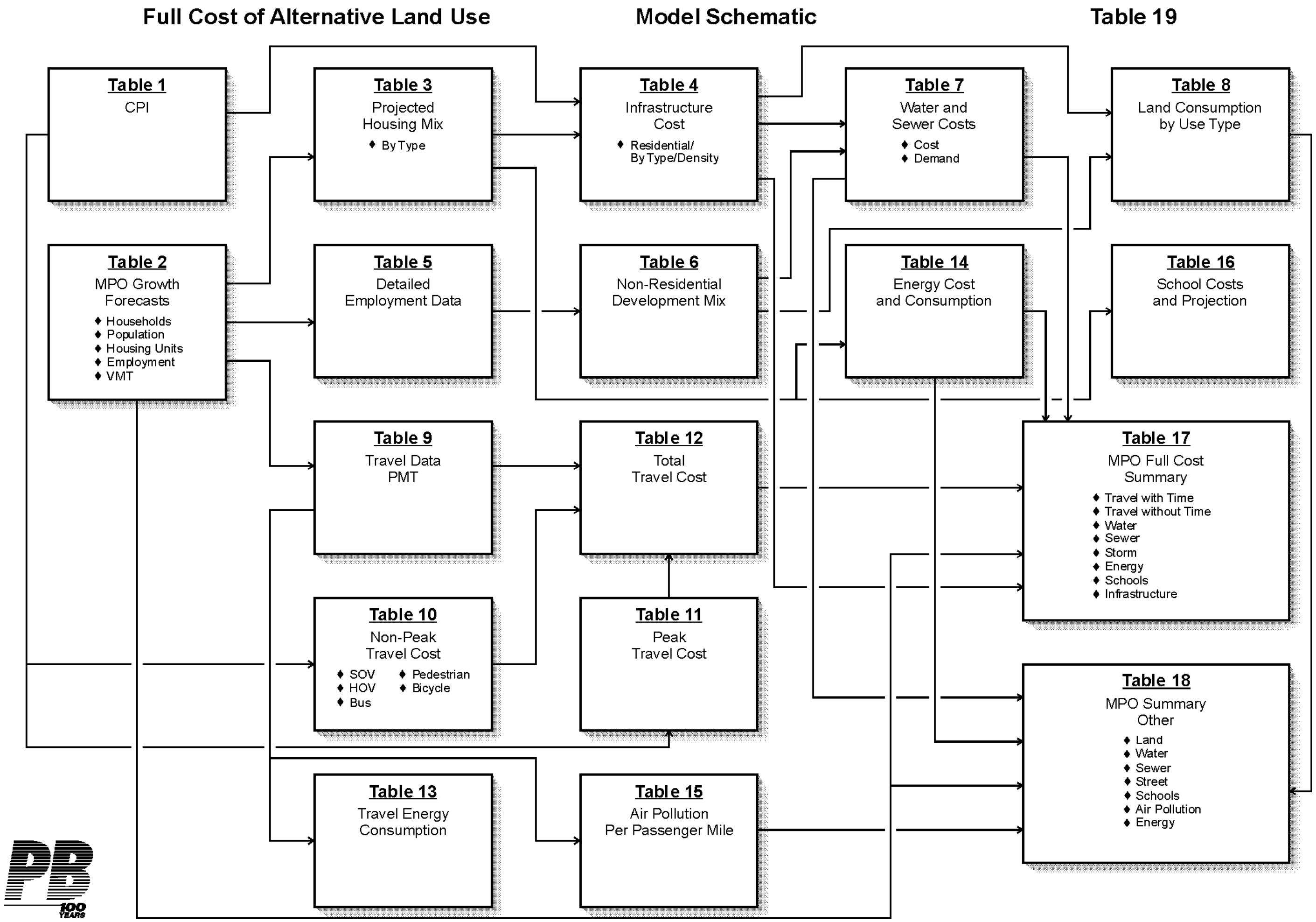
1.1. These data are available for a necessary conversion of prices into 1995 $. It is used currently in two places in the model.

TABLE 2 - MPO GROWTH FORECASTS - The data used in this spreadsheet are developed exogenously by the MPO.

2.1. Total Household and Population Projections –

- 2.1.1. Total Number of Households – Calculated Variable - First cell is a direct input, all other cells are equal to previous total plus change in number of households ($C_5 + B_6 = C_6$). Exogenous data need to match MPO Projections.
- 2.1.2. Projected Change in Number of Households – Exogenous Variable - Input and Scenario/Policy variable, can be used to change amount of projected growth in a given 5-Year period. Exogenous data need to match MPO Projections.
- 2.1.3. Average Household Size – Exogenous Variable - Used to calculated Projected Total Population ($C_5 * D_5 = F_5$) in a given time period. Input and Scenario/Policy variable, can be used to change amount of projected growth in a given 5 year period.
- 2.1.4. Projected Change in Number of Persons – Calculated Variable – Calculated by subtracting current year total persons from previous total persons ($F_6 – F_5 = E_6$).
- 2.1.5. Projected Total Population – Exogenous Variable – See 2.1.3. Exogenous data need to match MPO Projections.

Table 19: SCALDS MODEL



2.2. Total Housing Projections

2.2.1. Projected Change in Number of Housing Units - Calculated Variable – Calculated by subtracting current year total stock from previous total housing stock ($D_{19} – D_{18} = B_{19}$).

2.2.2. Projected Average Vacancy Rate - Exogenous Variable - Used to calculated Projected Total Housing Stock ($C_5*C_{18}=D_{18}$) in a given time period. Input and Scenario/Policy variable, can be used to change amount of projected growth in a given 5 year period

2.2.3. Projected Housing Stock - Calculated Variable – Estimated total number of housing units including vacant units in a metropolitan area. See 2.2.2

2.2.4. Percent of Total Housing Stock Classified Single Family - Exogenous Variable - Used to calculated Projected Number of Single Family Dwellings ($D_{18}*E_{18}=F_{18}$) in a given time period. Input and Scenario/Policy variable, can be used to change amount of projected growth in a given 5 year period.

2.2.5. Projected Number of Single Family Dwellings - Calculated Variable - Calculated to estimate the number of single family dwelling for use in other portions of this model ($D_{18} * E_{18} = F_{18}$).

2.2.6. Projected Number of Multifamily Dwellings - Calculated Variable - Calculated by subtracting single family housing stock from total housing stock ($D_{18} – F_{18} = G_{18}$).

2.3. Housing Mix Projection - This provides the links to Table 3

2.3.1. Projected Number of Single Family Dwellings - Calculated Variable – Is the same as 2.2.5. ($B_{31} = F_{18}$)

2.3.2. Projected Change in the Number of Single Family Dwellings - Calculated Variable - Calculated by subtracting current year SFD stock from previous total SFD stock ($B_{32} – B_{31} = C_{32}$).

2.3.3. Projected Number of Multiple Family Dwellings - Calculated Variable – Is the same as 2.2.6. ($D_{31} = G_{18}$)

2.3.4. Projected Change in the Number of Multiple Family Dwellings - Calculated Variable - Calculated by subtracting current year MFD stock from previous total MFD stock ($D_{32} – D_{31} = E_{32}$).

2.4. Total Employment Projection - This provides links to Table 6.

2.4.1. Total Employment - Exogenous Variable – Exogenous data need to match MPO Projections.

2.4.2. Projected Change in Total Employment - - Calculated Variable - Calculated by subtracting current year Total Employment from previous Total Employment ($B_{45} – B_{44} = C_{45}$).

2.4.3. Percent of Jobs Projected to be Retail - Exogenous Variable – Exogenous data that need to match MPO Projections. Input and Scenario/Policy variable, can be used to change amount of projected growth in a given 5 year period.

2.4.4. Projected Number of Retail Jobs - Calculated Variable - Calculated to estimate the number of retail jobs for use in other portions of this model (D_{44} * B_{44} = E_{44}).

2.4.5. Projected Change in Total Retail Employment - - Calculated Variable - Calculated by subtracting current year Projected Retail Jobs from previous years Projected Retail Jobs (E_{45} – E_{44} = F_{45}).

2.4.6. Projected Change in Total NON Retail Employment - Calculated Variable - Calculated by subtracting current year Projected Retail Jobs from previous years Total Employment (B_{44} – F_{44} = G_{45}).

2.5. Total Travel Projection – VMT

2.5.1. Total Daily VMT - Exogenous Variable and Calculated Variable - First two cells are directly from MPO data. Next cells are calculated to equal MPO data with the equation (B59 = F7 * D59). Daily VMT per person is adjusted until Total Daily VMT is equal to MPO projection for base case.

2.5.2. Projected Change in Daily VMT - Calculated Variable - Calculated by subtracting current year Daily VMT from previous years Daily VMT (B_{58} – B_{57} = C_{58}).

2.5.3. Daily VMT Per Person - Exogenous Variable and Calculated Variable – See 2.5.1 First two cells are directly from MPO data. For next cells Daily VMT per person is adjusted until Total Daily VMT is equal to MPO projection for base case. Input and Scenario/Policy variable, can be used to change amount of projected growth in a given 5 year period.

2.5.4. Estimated Total Annual VMT - Calculated Variable - Calculated by using the following formula (E_{57} = B_{57} * 330)

2.5.5. Projected Change in Annual VMT - - Calculated Variable - Calculated by subtracting current year Estimated Total Annual VMT from previous years Estimated Total Annual VMT (E_{58} – E_{57} = F_{58}).

2.6. Road System - These data are exogenous and are linked to Table 18

TABLE 3 – Projected Housing Units in MPO: The distribution in this table is strongly linked to Local Infrastructure Cost – Table 4

3.1. Projected Housing Units Linked to Table 2 at 2.3.1 and 2.3.3

3.2. Detailed Housing Mix – Total Number of Housing Units by Type – This is a summary table calculated from 3.3

3.3. Projected Change in the Number of Units by Type - Calculated variable. Column B contains the total number of units and percent of existing SFD or MFD units in a given land use type. Columns C through H are calculated variables. Enter the percent of either total new SFD or total new MFD projected to be created during a five year period and the variable is calculated using the following equations (SFD – C_{56} = C_{53} * C_{57} or MFD – C_{71} = C C_{72} * C_{54}). The results of these allocation as summarized in 3.2. Percentages (SFD or MFD) are input and Scenario/Policy variables, which can be used to change amount of projected growth in a given 5-year period.

TABLE 4 – Local Public Infrastructure Capital Cost Per Unit by Land Use Type –

4.1. CPI Cost Inflator – Calculated from CPI Table 1

4.2. Residential Land Use Type - Exogenous Variable – Land use cost by residential land use type and density are summarized in Column G. Policy or scenarios can be implemented by changing this value.

4.3. Estimated Infrastructure Cost From Proposed Housing Mix – Aggregate cost for 5 years projected using the cost in 4.2 Column G and 3.3 Costs are summarized in Column I and Row 112 and 114.

TABLE 5 – Detailed Employment Data – Linked back to Table 2 and forward to Table 6

5.1. Projected Total Employment – Exogenous Variable and Calculated Variable – Columns C through F are exogenous. These data should match MPO for these time periods. Columns G through K are projections and can be adjusted as policy variables for scenarios. The Retail Employment is linked to 2.4.4 and the Total Employment is linked to 2.4.1. The subtotal in Row 17 is used to insure that all of the jobs are accounted for and will equal the Total Employment when this is the case.

5.2. Projected Change in Employment - Calculated Variable - Calculated by subtracting current year employment by sector from previous year's employment by sector ($G_7 - F_7 = G_{23}$).

TABLE 6 – Non Residential Development Mix – Linked back to Table 5 and forward to Table 7

6.1. Employment Type - Exogenous Variable – From national studies
- 6.1.1. Structure Percentages - Exogenous Variable – Can be varied for scenarios.
- 6.1.2. Structure Type - Exogenous Variable - Can be varied for scenarios.
- 6.1.3. Non Residential FAR - Can be varied for scenarios.

6.2. Employment By Industry Sector - Column B is linked to 5.1 and Columns C through H are linked to 5.2.

6.3. Change in Employment by Building Type – Calculated Variable - Employment numbers in 6.2 are allocated to building type using the factors set out in 6.1.1, 6.1.2, and 6.1.3.

6.4. Total Employment by Building Type – Calculated Variable - Total Employment by building type is calculated by adding the change in employment to the previous year's total employment ($C_{63} = B_{63} + C_{52}$)

TABLE 7 – Water and Sewer Costs – Linked back to Table 3 and Forward to Tables 17 and 18

7.1. Land Use Type – Demand - Exogenous Variable – Can be varied for scenarios

7.2. Annual Private Operating Cost - Exogenous Variable – Can be varied for scenarios

7.3. Projected Change in Daily Water Demand by Land Use and Building Type in Gallons - Calculated Variable – Values are calculated using the demand factors in 7.1 and the number of residential units by type in 3.3 employment by building type in 6.4.

7.4. Projected Daily Total Water Demand - Calculated Variable – the sum of the demand in 7.3

7.5. Projected Annual Public Water Demand in EDU 's - Calculated Variable – Demand in 7.4 divided by factors from 7.2.

7.6. Projected Annual Private Water Cost - Calculated Variable – number of EDU's from 7.5 multiplied by cost from 7.2

7.7. Projected Change in Daily Sewer Demand by Land Use and Build ing Type in Gallons - Calculated Variable – Values are calculated using the demand factors in 7.1 and the number of residential units by type in 3.3 employment by building type in 6.4.

7.8. Projected Daily Total Sewer Demand - Calculated Variable – the sum of the demand in 7.7

7.9. Projected Annual Public Sewer Demand in EDU's - Calculated Variable – Demand in 7.8 divided by factors from 7.2.

7.10. Projected Annual Private Sewer Cost - Calculated Variable – number of EDU's from 7.9 multiplied by cost from 7.2

7.11. Projected Annual Private Costs Storm Water Systems - Calculated Variable – number of EDU's from 7.9 multiplied by cost from 7.2

TABLE 8 – Land Consumption by Use Type - Linked back to Tables 3 and 6 and forward to Table 18

8.1. Residential Uses - Calculated Variable – Number of housing units from Table 3.3 multiplied by a density factor based on Table 3.3

8.2. Non Residential Uses - Calculated Variable – Number of employees form Table 6.4 divided by density factors from Table 6.1.3.

TABLE 9 – Travel Data – PMT Linked back to Table 2 and forward to Tables 12, 13, and 15.

9.1. Person Trips by Mode - Exogenous Variable – National and local numbers but can be varied to construct scenarios based on changes in travel patterns.

9.2. Average Number of Persons Per Vehicle - Exogenous Variable – National and local numbers but can be varied to construct scenarios based on changes in travel patterns.

9.3. Person Trips Per Household - Exogenous Variable – National and local numbers but can be varied to construct scenarios based on changes in travel patterns.

9.4. Projected Total Number of Person Trips Average Weekday - Calculated Variable – Estimated by multiplying total household from Table 2 and average trips per household in 9.3. Allocated to trip types using allocations in 9.1

9.5. Projected Average Weekday Person Miles Traveled (AWD PMT) - Calculated Variable – Estimated by multiplying number of trips in 9.4 times average trip length in 9.1.

9.6. Projected Annual Personal Mile Traveled - Calculated Variable – Estimated multiplying daily miles by 330 to convert to annual PMT.

TABLE 10 – Non Peak Travel Costs - Linked to Table 12

10.1. Single Occupancy Vehicles - Calculated Variable – Calculated based on cost of travel cost analysis using national studies. Local numbers can be substituted based on local studies for the purposes of scenario building.

10.2. High Occupancy Vehicles - Calculated Variable – Calculated based on cost of travel cost analysis using national studies. Local numbers can be substituted based on local studies for the purposes of scenario building.

10.3. Transit Bus - Calculated Variable – Calculated based on cost of travel cost analysis using national studies. Local numbers can be substituted based on local studies for the purposes of scenario building.

10.4. Bicycle - Calculated Variable – Calculated based on cost of travel cost analysis using national studies. Local numbers can be substituted based on local studies for the purposes of scenario building.

10.5. Pedestrian - Calculated Variable – Calculated based on cost of travel cost analysis using national studies. Local numbers can be substituted based on local studies for the purposes of scenario building.

TABLE 11 – Peak Travel Costs - Linked to Table 12

11.1. Single Occupancy Vehicles - Calculated Variable – Calculated based on cost of travel cost analysis using national studies. Local numbers can be substituted based on local studies for the purposes of scenario building.

11.2. High Occupancy Vehicles - Calculated Variable – Calculated based on cost of travel cost analysis using national studies. Local numbers can be substituted based on local studies for the purposes of scenario building.

11.3. Transit Bus - Calculated Variable – Calculated based on cost of travel cost analysis using national studies. Local numbers can be substituted based on local studies for the purposes of scenario building.

11.4. Bicycle - Calculated Variable – Calculated based on cost of travel cost analysis using national studies. Local numbers can be substituted based on local studies for the purposes of scenario building.

11.5. Pedestrian - Calculated Variable – Calculated based on cost of travel cost analysis using national studies. Local numbers can be substituted based on local studies for the purposes of scenario building.

TABLE 12 – Total Travel Cost - Linked back to Table 10 and 11 and forward to Table 17

12.1. Unit Costs – Calculated Variable – Linked to table 11 and 12

12.2. Projected Average Weekday PMT - Calculated Variable – Linked to Table 9.5

12.3. Projected Daily Peak PMT - Calculated Variable – Table 12.2 allocated by factors in 12.1

12.4. Projected Daily Non Peak PMT - Calculated Variable – Table 12.2 allocated by factors in 12.1

12.5. Estimated Daily Peak Travel Costs - Calculated Variable – Table 12.3 multiplied by cost from 12.1.

12.6. Estimated Daily NON Peak Travel Costs - Calculated Variable – Table 12.4 multiplied by cost from 12.1.

12.7. Estimated Daily Peak Travel Cost Without Value of Time - Calculated Variable – Table 12.3 multiplied by cost from 12.1.

12.8. Estimated Daily NON Peak Travel Cost Without Value of Time - Calculated - Variable Table 12.4 multiplied by cost from 12.1.

12.9. Estimated Annual Peak Travel Cost - Calculated Variable – Table 12.4 times 330

12.10. Estimated Annual Non Peak Travel Cost - Calculated Variable – Table 12.5 times 330

12.11. Estimated Annual Total Travel Cost All Hours - Calculated Variable – Table 12.9 plus 12.10

12.12. Estimated Annual Peak Travel Cost Without Value of Time - Calculated Variable – Table 12.7 times 330

12.13. Estimated Annual Non Peak Travel Cost Without Value of Time - Calculated Variable – Table 12.8 times 330

12.14. Estimated Annual Travel Costs All Hours Without Value of Time - Calculated Variable – Table 12.12 plus 12.13

TABLE 13 – Transportation Energy Consumption Linked back to Table 9

13.1. National Average Energy Consumption - Exogenous Variable – Based on National studies (Places3 form USDOE)

13.2. Projected Annual PMT - Calculated Variable - Copied from Table 9.6

13.3. Projected Annual Transportation Energy Consumption - Calculated Variable - Table 13.2 multiplied by factors in Table 13.1

13.4. Projected Annual Energy Transportation Energy Cost - Calculated Variable - Table 13.2 multiplied by factors in Table 13.1

TABLE 14 – Energy Cost and Consumption – Linked back to Table 3 and forward to Tables 17 and 18

14.1. Energy Conversion Value 1995 - Exogenous Variable – Based on national studies (Places3 form USDOE)

14.2. Total Annual Energy Operation Cost per Household by Land Use Type – Exogenous Variable – Based on National studies (Places3 from USDOE)

14.3. Total Annual Energy Used in MMBtu - Calculated Variable – Table 3.2 times factors in Table 14.1

14.4. Total Annual Energy Used in $/Year - Calculated Variable - Table 3.2 times factors in Table 14.1

TABLE 15 – Air Pollution Per Passenger Mile Linked back to Table 9

15.1. Emission Rate for Selected Transportation Mode - Exogenous Variable – Based on national studies

15.2. Transit Passenger Mile Allocation - Exogenous Variable – Based on local studies

15.3. Total Annual PMT - Calculated Variable - Copied from Table 9.6

15.4. Annual Tons of HC Produced - Calculated Variable - Table 15.3 times factors in Table 15.1

15.5. Annual Tons of CO Produced - Calculated Variable - Table 15.3 times factors in Table 15.1

15.6. Annual Tons of NOx Produced - Calculated Variable - Table 15.3 times factors in Table 15.1

15.7. Annual Tons of SOx Produced - Calculated Variable - Table 15.3 times factors in Table 15.1

15.8. Annual Tons of PM Produced - Calculated Variable - Table 15.3 times factors in Table 15.1

TABLE 16 – School Costs and Projections Linked to Table 3

16.1. Number of School Age Children - Exogenous Variable – Based on national studies

16.2. Public Expenditures - Exogenous Variable – Based on local studies

16.3. Projected Housing Types - Calculated Variable – Summarized from Table 3.2

16.4. Projected Total Number of Public School Students - Calculated Variable – Table 16.3 times factors in Table 16.1

16.5. Projected Annual Total Expenditures for Public Education - Calculated Variable – Table 16.3 times factors in Table 16.2

APPENDIX B

SPREADSHEET TABLES

APPENDIX C

BIBLIOGRAPHY

BIBLIOGRAPHY

"Bye-bye Suburban Dream: Fifteen Ways to Fix the Suburbs." 1995. *Newsweek* CXXV, 20 (April).

1000 Friends of Oregon. 1995. *LUTRAQ.* Vol. 6. Portland, OR.

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

Aberger, Will, and Luther Propst. 1992. *Successful Communities: Managing Growth to Protect Distinctive Local Resources.* Washington, DC: Conservation Foundation.

Abrams, Charles. 1971. *The Language of Cities.* New York: Viking Press.

Adams, Thomas, Edward M. Bassett, and Robert Whitten. 1929. *Neighborhood and Community Planning: Regional Survey,* Vol VII. Committee on Regional Plan of New York and Its Environment.

Adelaja, A. O., D. Kerr, and K. Rose-Tank. 1989. "Economic and Equity Implications of Land Use Zoning in Suburban Agriculture." *Journal of Agricultural Ethics* 2: 97-112.

Allen, Elliot, Michael McKeever and Jeff Mithcum 1996. *The Energy Yardstick: Using Place^{3}s to Create More Sustainable Communities,* DE-FG49-94R900027, Salem Oregon, Oregon Department of Energy

Al-Mosaind, M. A., K. J. Dueker, and J. G. Strathman. 1993. "Light Rail Transit Stations and Property Values: A Hedonic Price Approach." *Transportation Research Record* 1400: 90–4.

Altshuler, Alan A. 1977. "Review of *The Costs of Sprawl*." *Journal of the American Planning Association* 43, 2: 207-9.

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

American Automobile Association (AAA) 1995. *Your Driving Costs.*

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

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

American Farmland Trust. 1992b. *The Cost of Community Services in Three Pioneer Connecticut Valley Towns: Agawam, Deerfield, and Gill.* Washington, DC: AFT.

American Farmland Trust. 1994. *Farming on the Edge: A New Look at the Importance and Vulnerability of Agriculture Near American Cities.* Washington, DC: AFT.

American Farmland Trust. 1997. *Farming on the Edge*. DeKalb, IL: AFT

American Planning Association (APA). 1997. *Growing Smart Legislative Guidebook (Phase I - Interim Edition).* Chicago, IL: APA.

Anderson, William P., Pavlos S. Kanaroglou, and Eric J. Miller. 1996. "Urban Form Energy and the Environment: A Review of Issues, Evidence and Policy." *Urban Studies* 33, 1: 7-35.

Andrews, James H. 1996. "Going by the Numbers." *Planning* (September): 14-18.

Andrews, Marcellus. 1994. "On the Dynamics of Growth and Poverty in Cities." *Citiscape* 1, 1 (August): 53-73.

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

Archer, R. W. 1973. "Land Speculation and Scattered Development: Failures in the Urban-Fringe Market. *Urban Studies* 10, 3: 367-72.

Archimore, A. 1993. "Pulling the Community Back into Community Retail." *Urban Land* 52, 8: 33-8.

Arendt, Randall et al. 1994. *Rural by Design*. Washington, DC: American Planning Association.

Arendt, Randall. 1994. *Designing Open Space Subdivisions: A Practical Step-by-Step Approach.* Natural Lands Trust, Inc.

Arendt, Randall. 1996. *Conservation Design for Subdivisions: A Practical Guide to Creating Open Space Networks.* New York, NY: Island Press.

Armstrong, R. J., Jr. 1994. *Impacts of Commuter Rail Service as Reflected in Single-Family Residential Property Values.* Paper presented at the 73rd Annual Meeting of the Transportation Research Board, Washington, DC.

Arrington, G. B., Jr. 1995. *Beyond the Field of Dreams: Light Rail and Growth Management in Portland.* Portland, OR: Tri-Met.

Audirac, Ivonne, A. H. Shermyen, and M. T. Smith. 1990. "Ideal Urban Form and Visions of the Good Life: Florida's Growth Management Dilemma." *Journal of the American Planning Association* 56 (Autumn): 470-482.

Audirac, Ivonne, and Maria Zifou. 1989. *Urban Development Issues: What is Controversial in Urban Sprawl? An Annotated Bibliography of Often-Overlooked Sources*. Council of Planning Librarians. CPL Bibliography 247.

Avin, Uri P. 1993. *A Review of the Cost of Providing Government Services to Alternative Residential Patterns.* Columbia, MD: LDR International.

Babcock, Richard F. 1966. *The Zoning Game.* Madison, WI: University of Wisconsin Press.

Bahl, Roy M. 1968. “A Land Speculation Model: The Role of the Property Tax as a Constraint to Urban Sprawl.” *Journal of Regional Science* 8, 2: 199-208.

Baldassare, Mark. 1986. *Trouble in Paradise: The Suburban Transformation of America.* New York: Columbia University Press.

Baltimore County. 1978. *Growth Management Program Technical Memorandum No. 11, Environmental Assessment.* Towson, Baltimore County, MD.

Bank of America, California Resources Agency, Greenbelt Alliance, Low-Income Housing Fund. 1995. *Beyond Sprawl: New Patterns of Growth to Fit the New California.* San Francisco: Bank of America et al.

Barnett, Jonathan. 1995. *The Fractured Metropolis: Improving the New City, Restoring the Old City, Reshaping the Region.* New York: HarperCollins.

Baumann D., and B. Dziegielewski. 1990. “Urban Water Demand Forecasting and Analysis of Conservation.” London: Planning and Management Consultants Ltd.

Beatley, Timothy, and David Brower. 1993. “Sustainability Comes to Main Street.” *Journal of the American Planning Association* 59, 5.

Beaumont, Constance. 1993. *Vermont.* Washington, DC: National Trust for Historic Preservation.

Beaumont, Constance. 1994. *How Superstore Sprawl Can Harm Communities—And What Citizens Can Do About It.* Washington, DC: National Trust for Historic Preservation.

Beaumont, Constance. 1996. *Historic Preservation.* Washington, DC: National Trust for Historic Preservation.

Beaumont, Constance. 1996. *Smart States, Better Communities.* Washington, DC: National Trust for Historic Preservation.

Bernick, M., and Robert Cevero. 1994. *Transit-based Residential Development in the United States: A Review of Recent Experiences.* Working Paper 611. Institute of Urban and Regional Development, University of California at Berkeley. March.

Berry, David, and Thomas Plaut. 1978. “Effects of Urbanization on Agricultural Activities.” *Growth and Change* 9, 3: 2-8.

Black, J. Thomas. 1996. “The Economics of Sprawl.” *Urban Land* 55, 3: 6–52.

Black, William, Dean Munn, Richard Black, and Jirong Xie 1996. *Modal Choices: An Approach to Comparing the Cost of Transportation Alternatives*, Bloomington Indiana, Transportation Research Center, Indiana University.

Blomquist, Glenn C., Mark C. Berger, and John P Hoehn. 1988. “New Estimates of Quality of Life in Urban Areas.” *American Economic Review* 78, 1: 89-107.

Bohi, Douglas R., and Joel Darmstadter. 1994. “Twenty Years after the Energy Crisis: What Lessons Were Learned?” *Resources* 116: 16-20.

Bookout, L. 1992. “Neotraditional Town Planning: The Test of the Marketplace.” *Urban Land* 51, 6: 12-17.

Bookout, L., and J. Wentling. 1988. “Density by Design.” *Urban Land* 47: 10-15.

Bourne, Larry S. 1992. “Self-Fulfilling Prophecies? Decentralization, Inner City Decline, and the Quality of Urban Life.” *Journal of the American Planning Association* 58: 509-513.

Bradbury, Katharine L., Anthony Downs, and Kenneth Small. 1982. *Urban Decline and the Future of American Cities.* Washington, DC: Brookings Institution.

Bradford, Susan. 1996. “The New Hometowns; Planned Unit Developments.” *Builder* 19, 7: 96.

Brindle, Ray. 1994. “Lies, Damned Lies and ‘Automobile Dependence.’” *Australasian Transport Research Forum* 19: 117-31.

Brueckner, J. K. 1990. “Growth Controls and Land Values in an Open City.” *Land Economics* 66: 237-248.

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): 325-37.

Burchell, Robert W. 1990. “Fiscal Impact Analysis: State of the Art and State of the Practice,” in Susan G. Robinson, ed., *Financing Growth: Who Benefits? Who Pays? and How Much?* Government Finance Officers Association.

Burchell, Robert W. and David Listokin. 1995. “Land, Infrastructure, Housing Costs, and Fiscal Impacts Associated with Growth: The Literature on the Impacts of Traditional versus Managed Growth.” Presented at the Alternatives to Sprawl Conference in Washington DC.

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

Burchell, Robert W. et al. 1992b. *Impact Assessment of the New Jersey Interim State Development and Redevelopment Plan, Report III: Supplemental AIPLAN Assessment.* Trenton: New Jersey Office of State Planning.

Burchell, Robert W. et al. 1997a. *Fiscal Impacts of Alternative Land Development Patterns in Michigan: The Costs of Current Development Versus Compact Growth.* Southeast Michigan Regional Council of Governments.

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

Burchell, Robert W., and David Listokin. 1978. *The Fiscal Impact Handbook: Estimating Local Costs and Revenues of Land Development.* New Brunswick, NJ: Center for Urban Policy Research, Rutgers University.

Burchell, Robert W., and David Listokin. 1982. *Energy and Land Use.* New Brunswick, NJ: Center for Urban Policy Research, Rutgers University.

Burchell, Robert W., and David Listokin. 1990. *Fiscal Studies.* Report to the Governor's Commission on Growth in the Chesapeake Bay Region. Annapolis, MD: 2020 Commission.

Burchell, Robert W., and David Listokin. 1991. *Fiscal Impact Analysis: A Manual and Software for Builders and Developers*. Washington, DC: National Association of Home Builders.

Burchell, Robert W., and David Listokin. 1994a. *Fiscal Impact Procedures and the Fiscal Impact Hierarchy.* Paper prepared for the Association for Budgeting and Financial Management, Annual Conference on Public Budgeting and Finance, Washington, DC. October.

Burchell, Robert W., and David Listokin. 1994b. *The Economic Effects of Trend versus Vision Growth in the Lexington Metropolitan Area.* Report prepared for Bluegrass Tomorrow, Lexington, KY. November.

Burchell, Robert W., and David Listokin. 1995a. *Land, Infrastructure, Housing Costs, and Fiscal Impacts Associated with Growth: The Literature on the Impacts of Traditional versus Managed Growth.* Paper prepared for "Alternatives to Sprawl" Conference, Brookings Institution, Washington, DC. March.

Burchell, Robert W., and David Listokin. 1995b. *The Economic Impacts of Trend versus Vision Development in the Lexington (Kentucky) Metropolitan Area.* Report prepared for Blue Grass Tomorrow. January.

Burchell, Robert W., and David Listokin. 1996. *Determinants of Municipal and School District Costs*. Report prepared for Sterling Forest Corporation, Tuxedo, New York.

Burchell, Robert W., and Emilie Schmeidler. 1993. *The Demographic and Social Difference Between Central Cities and Suburbs as They Relate to the Job Fulfillment of Urban Residents.* Paper presented at the National Conference on Metropolitan America in Transition: Implications for Land Use and Transportation Planning. Cambridge, MA: Lincoln Institute of Land Policy.

Burchell, Robert W., and Harvey S. Moskowitz. 1995. *Impact Assessment of DELEP CCMP versus STATUS QUO on Twelve Municipalities in the DELEP Region.* Report prepared for the Local Governments Committee of the Delaware Estuary Program. Philadelphia, PA. August 15.

Burchell, Robert W., and Naveed A. Shad. 1997. "The Incidence of Sprawl in the United States." Washington DC: Transportation Cooperative Research Program (TCRP H-10) (In Press).

Burchell, Robert W., David Listokin, and William R. Dolphin. 1993. *The Development Impact Handbook.* Washington, DC: Urban Land Institute.

Bureau of Labor Statistics 1997. *Consumer Price Index - http://stats.bls.gov/cgi-bin/surveymost - Series ID CUUR0000SA0, Washington DC.*

Burnell, James, and George Galster. 1992. "Quality of Life Measurement and Urban Size." *Urban Studies* 29, 5: 727-35.

Calthorpe, Peter G. 1993. *The Next American Metropolis: Ecology, Community, and the American Dream.* Princeton: Princeton University Press.

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.

Cameron, Michael W. 1994. *Efficiency and Fairness on the Road: Strategies for Unsnarling Traffic in Southern California.* New York: Environmental Defense Fund.

Carlson, Allan. 1996. "Two Cheers for the Suburbs." *American Enterprise* 7, 6.

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.

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

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

Cervero, Robert, M. Bernick, and J. Gilbert. 1994. *Market Opportunities and Barriers to Transit-Based Development in California.* Working Paper 621. Institute of Urban and Regional Development, University of California at Berkeley.

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.

Cervero, Robert. 1986. *Suburban Gridlock*. New Brunswick, NJ: Center for Urban Policy Research, Rutgers University.

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

Cervero, Robert. 1991a. “Congestion Relief: The Land-Use Alternative.” *Journal of Planning Education and Research* 10: 119-29.

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

Cervero, Robert. 1994a. “Transit-Focused Develop ment: Does It Draw People into Transit and Buses?” *IURD Universe* 4: 3-5.

Cervero, Robert. 1994b. “Transit Villages: from Idea to Implementation.” *Access* 5: 8-13.

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

Cervero, Robert. 1998. *The Transit Metropolis*. New York, NY: Island Press

CH2M Hill. 1993. *Cost of Providing Government Services to Alternative Residential Patterns: Literature Review.* Maryland• Pennsylvania•Virginia: Chesapeake Bay Program.

Chesapeake Bay Executive Council. 1988. *Population Growth and Development in the Chesapeake Bay Watershed to the Year 2020: The Report of the Year 2020 Panel of Experts.* Annapolis, MD: Chesapeake Bay Executive Council.

City of San Diego. 1984. *A Review and Evaluation of Progress in Achieving the Goals and Objectives of the City's Residential Growth Management Strategy.* San Diego, CA.

Clark, Charles S. 1995. “Revitalizing the Cities: Is Regional Planning the Answer?” *CQ Researcher* 5, 38 (October 13): 897-920.

Clavell, Pierre. 1986. *The Progressive City.* New Brunswick, NJ: Rutgers University Press.

Clawson, Marion. 1962. “Urban Sprawl and Speculation in Suburban Land.” *Land Economics* 38, 2: 99-111.

Cochrun, Stephen E. 1994. “Understanding and Enhancing Neighborhood Sense of Community.” *Journal of Planning Literature* 9, 1: 92-99.

Consultants. 1980. “Source Material Task II—Needs Assessment for the New Jersey Statewide Water Supply Plan.” New Jersey Department of Environmental Protection, Division of Water Resources.

Cook, Christine C. 1988. "Components of Neighborhood Satisfaction: Responses from Urban and Suburban Single-Parent Women." *Environment and Behavior* 20, 2: 115-149.

Coughlin, Robert E., and John C. Keene. 1981. *The Protection of Farmland: A Reference Guidebook for State and Local Governments*. Report prepared for the National Agricultural Lands Study. Amherst, MA: Regional Science Research Institute.

Crane, R. 1996. "Cars and Drivers in the New Suburbs: Linking Access to Travel in Neo-traditional Planning." *Journal of the American Planning Association* 62, 1: 51-65.

Cushing, Brian J. 1987. "Location Specific Amenities, Topography, and Population Migration." *Annals of Regional Science* 21, 2: 74-85.

Dahl, Thomas E. 1990. *Wetlands Losses in the United States: 1780s-1980s.* Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service.

Daniels, P. W. 1972. "Transport Changes Generated by Decentralized Offices." *Regional Studies* 6: 273-89.

Daniels, T. L., and J. W. Keller. 1991. "What Do You Do When Wal-Mart Comes to Town?" *Small Town* (September-October): 14-18.

Davis, Judy, and Samuel Seskin. 1997. "Impacts of Urban Form on Travel Behavior." *The Urban Lawyer* 29, 2 (Spring).

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

Davis, Mary. 1993. "The Gautreaux Assisted Housing Program." In Thomas C. Kingsley and Margery A. Turner, eds., *Housing Markets and Residential Mobility.* Washington, DC: Urban Institute Press: 243–252.

DeChiara, Joseph, and Lee E. Koppelman. 1975. *Manual of Housing/Planning and Design Criteria.* Englewood Cliffs, NJ: Prentice-Hall.

DeCorla-Souza, P. 1992. *The Impacts of Alternative Urban Development Patterns on Highway System Performance.* Paper presented at Institute of Transportation Engineers International Conference, Washington, DC.

DeGrove, John M. 1989. "Growth Management and Governance." In D. Brown et al., *Understanding Growth Management* .Washington, DC: Urban Land Institute.

DeGrove, John M. 1990. "The Pay As You Go Challenge: Financial Management in a Growth Environment." In Susan G. Robinson, ed. *Financing Growth: Who Benefits? Who Pays? How Much?* Washington, DC: Government Finance Officers Association.

Delafons, John. 1962. *Land Use Controls in the United States*. Cambridge, MA: Harvard-MIT Joint Center for Urban Studies.

Delucchi, Mark. 1996a. *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.

Delucchi, Mark and Donald McCubbin 1996b. *The Social Cost of the Health Effects of Motor-Vehicle Air Pollution – Report # 11*, Davis, California, Institute of Transportation Studies, University of California, Davis

Delucchi, Mark and James Murphy 1996c. *Review of Some Literature on The Social Cost of Motor-Vehicle Use – Report # 3*, Davis, California, Institute of Transportation Studies, University of California, Davis.

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

Dowall, David E. 1984. *The Suburban Squeeze.* Berkeley, CA: University of California Press.

Dowall, David E., and John Landis. 1982. "Land Use Controls and Housing Costs: An Examination of San Francisco Bay Area Communities." *American Real Estate and Urban Economics Association Journal* 10 (Spring): 67-93.

Downing, P. B., and R. D. Gustely. 1977. "The Public Service Costs of Alternative Development Patterns: A Review of the Evidence." In P.B. Downing, ed., *Local Service Pricing Policies and Their Effect on Urban Spatial Structure.* Vancouver: University of British Columbia Press.

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

Downs, Anthony. 1970. "Uncompensated Nonconstructive Costs Which Urban Highways and Urban Renewal Impose Upon Residential Households." In Julius Margolis, ed., *The Analysis of Public Output.* New York, NY: National Bureau of Economic Research, Inc.

Downs, Anthony. 1973. *Opening Up the Suburbs: An Urban Strategy for America.* New Haven, CT: Yale University Press.

Downs, Anthony. 1981. *Neighborhoods and Urban Development*. Washington, DC: Brookings Institution.

Downs, Anthony. 1985 *The Revolution in Real Estate Finance.* Washington, DC: Brookings Institution.

Downs, Anthony. 1992. *Stuck In Traffic*. Washington, DC and Cambridge, MA: The Brookings Institution and The Lincoln Institute of Land Policy.

Downs, Anthony. 1994. *New Visions for Metropolitan America*. Washington, DC. and Cambridge, MA: The Brookings Institution and Lincoln Institute of Land Policy.

Drucker, Peter F. 1989. “Information and the Future of the City.” *Urban Land* 48: 38-9.

Drucker, Peter F. 1992. “People, Work, and the Future of the City.” In *Managing the Future.* New York: Dutton: 125-129.

Duany, Andres, and Elizabeth Plater-Zyberk. 1995. “Neighborhoods and Suburbs.” *Design Quarterly* (March): 10.

Dubin, R. “Commuting Patterns and Firm Decentralization.” 1991. *Land Economics*, 67: 121-129.

Dueker, K. J., J. G. Strathman, I. P. Levin, and A. G. Phipps. 1983.“Rural Residential Development With Metropolitan Areas.” *Computers, Environment and Urban Systems* 8: 121-129.

Duensing, Edward. 1977. *Suburban Shopping Centers versus the Central Business District: A Bibliography.* Monticello, IL: Vance Bibliographies.

Duffy, N.E. 1994. “The Determinants of State Manufacturing Growth Rates: A Two-Digit-Level Analysis.” *Journal of Regional Science* 34 (2): 137-162.

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

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.

Dunphy, R. T., D. L. Brett, S. Rosenbloom, and A. Bald. 1997. *Moving Beyond Gridlock: Traffic and Development*. Washington, DC: ULI-Urban Land Institute.

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

Durand, Roger, Kim Hill, and Laura Roy. 1986. “Citizen Reactions to Urban Growth: Attitudes Toward Quality of Life and Local Public Services in an Expanding Sunbelt Community.” *Journal of Urban Affairs* 8 (Fall): 15-26.

Dyckman, John W. 1976. *Speculations on Future Urban Form.* Working Paper, Johns Hopkins University, Center for Metropolitan Planning and Research.

Dziegielewski, B., and J. J. Boland. 1989. “Forecasting Water Use: The IWR—MAIN Model.” *Water Resources Bulletin* 25, 1 (February).

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

ECONorthwest, Parsons Brinckerhoff Quade and Douglas, and COMSIS Corporation. 1995. *Least-Cost Planning: Principles, Applications and Issues*. US. Department of Transportation, Federal Highway Administration, Office of the Environment and Planning.

ECONorthwest. 1993. *Environmental Externalities and Electric Utility Regulation*. Washington, DC.: US. Department of Energy.

ECONorthwest. 1994. *Evaluation of No-Growth and Slow-Growth Policies for the Portland Region*. Metro.

ECONorthwest. 1996. *Summary: Technical Reports for 2040 Means Business*. ECONorthwest. November.

Ehrenberg, R. G., and R. S. Smith. 1994. *Modern Labor Economics: Theory and Public Policy.* 5th ed. HarperCollins.

Ellwood, David T. 1986. "The Spatial Mis match Hypothesis: Are There Teen-age Jobs Missing in the Ghetto?" In Richard B. Freeman and Harry J. Holzer, eds., *The Black Youth Employment Crisis.* Chicago, IL: University of Chicago Press.

Environmental Protection Agency (EPA). 1973. *The Quality of Life Concept: A Potential New Tool for Decision Makers.* Washington, DC: EPA, Office of Research and Monitoring, Environmental Studies Division.

Environmental Protection Agency. 1971. *Community Noise.* Washington, DC: U.S. Government Printing Office.

Etzioni, Amitai. 1993. *The Spirit of Community: Rights, Responsibilities, and the Communitarian Agenda.* New York: Crown Publishers.

European Conference of Ministers of Transport. 1994. *Short-Distance Passenger Travel*. Report of 96th Round Table on Transport Economics, Paris, France.

Evaluation of City of San Diego Growth Management Program. 1978. Baltimore County, Maryland.

Ewing, Reid H. 1994. "Characteristics, Causes, and Effects of Sprawl: A Literature Review." *Environmental and Urban Issues* (Winter): 1-15.

Ewing, Reid. 1995b. "Beyond Density, Mode Choice, and Single-Purpose Trips." *Transportation Quarterly.* 49, 4:15-24.

Ewing, Reid, 1995c. "Measuring Transportation Performance." *Transportation Quarterly.* 49, 1:91-104.

Ewing, Reid. MaryBeth DeAnna, and Shi-Chiang Li. 1996. "Land-Use Impacts on Trip Generation Rates." *Transportation Research Record* 1518: 1-7.

Ewing, Reid. 1991. *Developing Successful New Communities.* Washington, DC: Urban Land Institute.

Ewing, Reid. 1995a. *Best Development Practices: Doing the Right Thing and Making Money at the Same Time.* Chicago: American Planning Association.

Ewing, Reid. 1997. "Is Los Angeles-Style Sprawl Desirable?" *Journal of the American Planning Association* 63, 1 (Winter): 107-126.

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.

Fannie Mae. 1985, 1989, 1992, 1994, 1996. *Survey of Residential Satisfaction of Housing Occupants.* Washington, DC: Federal National Mortgage Association (Fannie Mae).

Fannie Mae. 1995. 1996. *National Housing Survey.* Washington, DC: Federal National Mortgage Association (Fannie Mae).

Feagin, Joe R., and Robert Parker. 1990. *Building American Cities: The Urban Real Estate Game.* 2d ed. Englewood Cliffs, NJ: Prentice Hall.

Federal Bureau of Investigation. 1996. *Crime in the United States*. Press Release. U.S. Department of Justice, Federal Bureau of Investigation. October 13.

Federal Highway Administration 1995a. *Highway Statistics*, Washington DC, Federal Highway Administration

Federal Highway Administration 1995b. *Highway Taxes and Fees*, Report FHWA-PL-95-036, Washington D.C. Federal Highway Administration

Federal Transit Administration (FTA) 1994. *Transit Profiles in Urbanized Areas Exceeding 200,000 Population*, Washington DC, Federal Transit Administration.

Fischel, William A. 1985. *The Economics of Zoning Laws: A Property Rights Approach to American Land Use Controls.* Baltimore: Johns Hopkins University Press.

Fischel, William A. 1990. *Do Growth Controls Matter?* Cambridge, MA: Lincoln Institute of Land Policy. May.

Fischel, William A. 1990. *Do Growth Controls Matter?* Lincoln Institute of Land Policy. 1-68 pages.

Fischel, William A. 1997. Comment on Carl Abbott's "The Portland Region: Where City and Suburbs Talk to Each Other—and Often Agree." *Housing Policy Debate* 8, 1: 65-73.

Fischel, William. 1989. "What Do Economists Know About Growth Controls: A Research Review." In *Understanding Growth Management: Critical Issues and A Research Agenda*. Edited by David J. Brower, David R. Godschalk, and Douglas R. Porter. Washington D.C.: Urban Land Institute.

Fischer, Paul B. 1991. *Is Housing Mobility an Effective Anti-Poverty Strategy? An Examination of the Cincinnati Experience.* Cincinnati, OH: Stephen H. Wilder Foundation.

Fishman, Robert. 1987. *Bourgeois Utopia: The Rise and Fall of Suburbia.* New York: Basic Books.

Florida Advisory Council on Intergovernmental Relations (FACIR). 1996. *Impact Fees in Florida.* Tallahassee, FL: FACIR. November.

Florida Growth Management Act. 1985. *Local Government and Comprehensive Planning and Land Development Regulation Act of 1985.*

Fodor, Eben V. 1995. *The Real Cost of Growth in Oregon.* Preliminary report. Eugene, OR: Energy & Environmental Planning Associates. October.

Foster, Kathryn A. 1996. “Specialization in Government: The Uneven Use of Special Service Districts in Metropolitan Areas.” *Urban Affairs Review* 31, 3: 283-313.

Frank, James E. 1989. *The Costs of Alternative Development Patterns: A Review of the Literature*. Washington D.C.: Urban Land Institute. 46 pages.

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

Frank, James E., Downing, Paul B. 1988. “Patterns of Impact Fee Use.” In *Development Impact Fees: Policy Rationale, Practice, Theory, and Issues*. Edited by Arthur C. Nelson.

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

Freilich, Robert H. 1980. *Saving the Land: The Utilization of Modern Techniques of Growth Management to Preserve Rural and Agricultural America.* Illinois Farmers Home Administration.

Freilich, Robert H., and Bruce G. Peshoff. 1997. “The Social Costs of Sprawl.” *The Urban Lawyer* 29, 2: 183-198.

Freilich, Robert H., and S. Mark White. 1991. “Transportation Congestion and Growth Management: Comprehensive Approaches to Resolving America’s Major Quality of Life Crisis.” *Loyola University of Los Angeles Law Review* 24: 915.

Freilich, Robert H., Elizabeth A. Garvin, and S. Mark White. 1993. “Economic Development and Public Transit: Making the Most of the Washington Growth Management Act.” *University of Puget Sound Law Review* 16 (Spring): 949.

Fried, Carla, Leslie M. Marable, and Sheryl Nance-Nash. 1996. “Best Places to Live In America.” *Money* (July): 66-95.

Gabriel, Stuart A., Joe P. Mattey, and William L. Wascher. 1996. *Compensating Differentials and Evolution of the Quality-of-Life Among U.S. States*. San Francisco: Federal Reserve Bank of San Francisco. 96-07. June.

Gaffuri, E., and G. Costa. 1986. “Applied Aspects of Chronoergohygiene.” *Chronobiologia* 13: 39-51.

Gans, Herbert, J. Kasarda, and H. Molotch. 1982. “Symposium: The State of the Nation’s Cities.” *Urban Affairs Quarterly* 18, 2: 163-86.

Garreau, Joel. 1991. *Edge City: Life on the New Frontier*. New York: Doubleday.

Georgia Conservancy. 1997. *Blueprints for Successful Communities: A Guide for Shaping Livable Places.* Atlanta, GA: The Georgia Conservancy.

Giuliano, Genevieve. 1995. “The Weakening Transportation—Land Use Connection.” *Access* 6 (Spring): 3-11.

Giuliano, Genevieve. 1995. “Land Use Impacts of Transportation Investments: Highways and Transit,” in Susan Hanson, ed., *The Geography of Urban Transportation.* 2nd ed. New York, NY: The Guilford Press.

Glaeser, Edward L. 1994. “Cities, Information, and Economic Growth.” *Citiscape* 1, 1 (August): 9-47.

Glickman, Norman J., Michael L. Lahr, and Elvin K. Wyly. 1996. *State of the Nation’s Cities.* Report and database prepared for U.S. Department of Housing and Urban Development, Washington, DC.

Glynn, Thomas J. 1981. “Psychological Sense of Community Measurement and Application.” *Human Relations* 34, 7: 789-818.

Goldberg, Michael A., and John Mercer. 1986. *The Myth of the North American City.* Vancouver: University of British Columbia Press.

Gomez-Ibanez, Jose A. 1991. “A Global View of Automobile Dependence.” *Journal of the American Planning Association* 5*7.*

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.

Gordon, Peter and Harry W. Richardson. 1997. “Are Compact Cities a Desirable Planning Goal?” *Journal of the American Planning Association* 63, 1 (Winter).

Gordon, Peter, and H. L. Wong. 1985. “The Cost of Urban Sprawl: Some New Evidence.” *Environment and Planning A* 17: 661-66.

Gordon, Peter, and Harry W. Richardson. 1989a. “Gasoline Consumption and Cities: A Reply.” *Journal of the American Planning Association* 55*:* 342-46.

Gordon, Peter, and Harry W. Richardson. 1989b. “Notes from the Under ground: The Failure of Urban Mass Transit.” *Public Interest* 94: 77-86.

Gordon, Peter, and Harry W. Richardson. 1994a. “Sustainable Congestion.” In J. Brotchie, ed., *Cities in Competition: The Emergence of Productive and Sustainable Cities for the 21st Century*.

Gordon, Peter, and Harry W. Richardson. 1994b. *Geographic Factors Explaining Worktrip Length Changes.* Prepared for the U.S. Department of Transportation, Federal Highway Administration.

Gordon, Peter, and Harry W. Richardson. 1994c. “Congestion Trends in Metropolitan Areas.” In National Research Council, *Curbing Gridlock: Peaking Period Fees to Relieve Traffic Congestion.*. Washington, DC; National Academy Press. 1-31

Gordon, Peter, and Harry W. Richardson. 1995. “Beyond Polycentricity: The Dispersed Metropolis, Los Angeles, 1970-90.” *Journal of the American Planning Association* 61.

Gordon, Peter, and Harry W. Richardson. 1996. “Los Angeles Among Other CMSAs: Outlier or the Norm?” *Environment and Planning A.*

Gordon, Peter, and Harry W. Richardson. 1997. “The Destiny of Downtowns: Doom or Dazzle*?” Lusk Review* (Fall): 63-76.

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): 416-420.

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: 416-420.

Gordon, Peter, Harry W. Richardson, and Y. Choi. 1992. “Tests of the Standard Urban Model: A Micro (Trade-off) Alternative.” *Review of Urban and Regional Development Studies* 4, 1: 50-66.

Gordon, Peter. 1994. *Regional Science and Compact Cities*. School of Urban and Regional Planning, University of Southern California.

Gordon, Peter; Harry W. Richardson; and Gang Yu. 1997. “Metropolitan and Non-Metropolitan Employment Trends in the U.S.: Recent Evidence and Implications.” Los Angeles, CA: School of Urban Planning and Development and Department of Economics. University of Southern California,

Gottdiener, Mark. 1977. *Planned Sprawl: Private and Public Interests in Suburbia.* Beverly Hills, CA: Sage.

Gottlieb, Paul D. 1995. “Residential Amenities, Firm Location and Economic Development.” *Urban Studies* 32, 9: 1413-1436.

Governor's Commission on Growth in the Chesapeake Bay Region. 1991. *Fiscal Studies.* Baltimore, MD: Maryland Office of Planning.

Green, K. 1995. *Defending Automobility: A Critical Examination of the Environmental and Social Costs of Auto Use*. Policy Study No. 198. Los Angeles, CA: Reason Foundation. December.

Greene, David L. and Donald W. Jones. 1995. "The Full Costs and Benefits of Transportation: Conceptual and Theoretical Issues." Presented at the Conference of the Full Social Costs and Benefits of Transportation.

Greenwood, Michael J., Gary L. Hunt, Dan S. Rickman, and George I. Treyz. 1991. "Migration, Regional Equilibrium, and the Estimation of Compensating Differentials." *American Economic Review* 81, 5: 1382-1390.

Gross, Marilyn, and Richard Feldman 1996. *National Transportation Statistics 1996*, DOT-BTS-VNTSC-95-4, Washington DC, Bureau of Transportation Statistics

Growth Management Planning and Research Clearinghouse, University of Washington. 1993. *Literature Review of Community Impacts and Costs of Urban Sprawl.* Washington, DC: National Trust for Historic Preservation.

Haines, V. 1986. "Energy and Urban Form: A Human Ecological Critique." *Urban Affairs Quarterly* 21, 3: 337-53.

Hall, Bob, and Mary Lee Kerr. 1991. *1991-1992 Green Index: A State-By-State Guide to the Nation's Environmental Health.* Washington, DC: Island Press.

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

Handy, S. 1994. "Highway Blues: Nothing a Little Accessibility Can't Cure." *Access* 5: 3-7.

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.

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

Harris, C. 1992. "Bringing Land Use Ratios into the 90s." Planning Advisory Service Report. Chicago: American Planning Association.

Harrison, Bennett. 1974. "Discrimination in Space: Suburbanization and Black Unemployment in Cities." In George M. von Furstenburg, Bennett Harrison, and Ann Horowitz, eds., *Patterns of Racial Discrimination, Vol I: Housing.* Lexington, MA: Lexington Books.

Hartshorn, Truman A. 1980. *Interpreting the City: An Urban Geography*. New York, NY: Wiley.

Hartshorn, Truman A., and Peter O. Muller. 1989. "Suburban Downtowns and the Transformation of Metropolitan Atlanta's Business Landscape," *Urban Geography* 10: 375-395.

Hartshorn, Truman A., and Peter O. Muller. 1992. "The Suburban Downtown and Urban Economic Development Today." In Edwin S. Mills and John F. McDonald, eds., *Sources of Metropolitan Growth.* New Brunswick, NJ: Center for Urban Policy Research, Rutgers University.

Harvey, G. 1990. *Relation of Residential Density to VMT per Resident: Oakland.* Metropolitan Transportation Commission.

Harvey, Greg and Elizabeth Deakin, 1993. *A Manual of Regional Transportation Modeling Practice for Air Quality Analysis – Version 1.0,* Washington DC, National Associations of Regional Councils.

Harvey, Robert Q., and W.A.V. Clark. 1965. "The Nature and Economics of Urban Sprawl." *Land Economics* 41, 1: 1-9.

Heikkila, E. et al. "What Happened to the CBD-Distance Gradient? Land Values in a Polycentric City." *Environment and Planning A* 21: 221–32.

Heimlich, Ralph E. 1989. "Metropolitan Agriculture—Farming in the City's Shadow." *Journal of the American Planning Association* 55, 4: 457-66.

Herbers, J. 1982. *The New Heartland: America's Flight Beyond the Suburbs and How it is Changing our Future.* Herbers Publishers.

Herson, Lawrence J. R. 1992. "The New Suburbanization: Challenge to the Central City." *Annals of the American Academy of Political and Social Science* 522: 184.

Hidlebaugh, Allen R. 1981. *Agricultural Land Data Sheet: America's Agricultural Land Base.* National Agricultural Lands Study, Wash ington, DC.

Hiss, Tony. 1990. *The Experience of Place.* New York: Vintage Books.

Hodge, G. 1981. "The Citification of Small Towns: A Challenge to Planning." *Plan Canada* 21: 43-7.

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

Howard County (Maryland) Planning Commission. 1967. *Howard County: 1985.* Howard County, MD: Howard County Planning Commission. April.

Hughes, Mark A. 1991. "Employment Decentralization and Accessibility—A Strategy for Stimulating Regional Mobility." *Journal of the American Planning Association* 57, 3: 288-98.

Hummon, D. 1990. *Commonplaces: Community Ideology and Identity in American Culture*. Binghamton, NY: SUNY Press.

Ihlanfeldt, Keith R. 1995. "The Importance of the Central City to the Regional and National Economy: A Review of the Arguments and Empirical Evidence." *Citiscape* 1, 2 (June): 125-150.

Ihlanfeldt, Keith R., and David L. Sjoquist. 1990. "Job Accessibility and Racial Differences in Youth Employment Rates." *American Economic Review* 80: 267-76.

Institute of Transportation Engineers. 1984. *Recommended Guidelines for Subdivision Streets.* Washington, DC: Institute of Transportation Engineers.

Isard, Walter, and Robert E. Coughlin. 1957. *Municipal Costs and Revenues Resulting from Growth.* Wellesley, MA: Chandler-Davis.

Jackson, Kenneth T. 1976. "The Effect of Suburbanization on the Cities." In P. Dolce, ed., *Suburbia: The American Dream and Dilemma.* Garden City, NY: Doubleday.

Jackson, Kenneth T. 1985. *Crabgrass Frontier: The Suburbanization of the United States.* New York: Oxford University Press.

Jacobs, Jane. 1961. *The Death and Life of Great American Cities*. New York: Vintage Books.

Jarrell, Stephen, and Roy M. Howsen. 1990. "Transient Crowding and Crime: The More 'Strangers' in an Area, the More Crime Except for Murder, Assault and Rape." *American Journal of Economics and Sociology* 49, 4: 483-494.

Johnson, Thomas G. 1987. "Fiscal Impacts of Economic Development." In *Responding to the Crisis in the Rural South: Highlights of Selected Public- and Private-Sector Initiatives.* Southern Rural Development Center, Mississippi State University.

Jones, L. L., and M. D. Woods. 1985. "Determining the Impacts of New Industry on Small Towns in Texas." *Small Town* (September-October): 22-5.

Jones, P. 1989. "Regional Shopping Centers—Planning Issues." *Town and Country Planning* 58, 10: 280-2.

Joseph, Nadine. 1992. "Mommy Myths; Attitudes Toward Working Mothers." *Redbook* (October): 130.

Kain, John. 1967. *Urban Form and the Costs of Urban Services.* Cambridge, MA: Harvard University.

Kain, John. 1988. "Choosing the Wrong Technology: Or How to Spend Billions and Reduce Transit Use." *Journal of Advanced Transportation* 21

Kain, John. 1991. "Trends in Urban Spatial Structure, Demographic Change, Auto and Transit Use, and the Role of Pricing." Statement prepared for the United States Senate, Committee on Environment and Public Works.

Kain, John. 1992. "The Spatial Mismatch Hypothesis: Three Decades Later." *Housing Policy Debate* 3, 2: 371-459.

Kaman Sciences Corporation. 1972. *Land Use Planning for Air Quality in the Pikes Peak Area.* Colorado Springs, CO: Kaman Sciences Corporation. August.

Kasarda, John D. 1990. "City Jobs and Residents on a Collision Course: The Urban Underclass Dilemma." *Economic Development Quarterly* 4, 4: 313-19.

Katz, Lawrence, and Kenneth Rosen. 1987. "The Interjurisdictional Effects of Growth Controls on Housing Prices." *Journal of Law and Economics* 30 (April): 149-60.

Katz, Peter. 1994. *The New Urbanism: Towards an Architecture of Community.* New York: McGraw Hill.

Kelbaugh, Douglas. 1993. "The Costs of Sprawl." *Cascadia Forum* 1: 20-26.

Kenworthy, J. and P. Newman. 1993. *Automobile DependenceÑ"The Irresistible Force"?* Murdoch University, Institute for Science and Technology Policy.

Kingsley, G. Thomas, and Margery Austin Turner, eds. 1993. *Housing Markets and Residential Mobility.* Washington, DC: Urban Institute Press.

Kitamura, R., L. Laidet, P. Mokhtarian, C. Buckinger, and F. Gianelli. 1994. *Mobility and Livable Communities.* State of California Air Resources Board.

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.

Knapp, Thomas A., and Philip E. Graves. 1989. "On the Role of Amenities in Models of Migration and Regional Development." *Journal of Regional Science* 29 (1): 71-87.

Koslowsky, Meni, and Moshe Krausz. 1994. "On the Relationship Between Commuting, Stress Symptoms, and Attitudinal Measures: A LISREL Application." *Journal of Applied Behavioral Science* 29, 4: 485-492.

Kotkin, Joel. 1996. "Make Way for the Urban Confederates." *American Enterprise* 7, 6.

Kotval, Zenia, and John R. Mullin. 1992. *A Fiscal Impact Analysis Technique: The Pawling Model.* Hadley, MA.

Krieger, Alex, ed. 1991. *Towns and Town-making Principles: The Work of Andres Duany and Elizabeth Plater-Zyberk.* New York: Rizzoli International Publishers.

Krote, James J. 1992. "Is Downtown Worth Saving?" *Planning* 58, 8: 148-62.

Kunstler, James. 1993. *The Geography of Nowhere: The Rise and Decline of America's Man-Made Landscape.* New York: Simon & Schuster.

Kunstler, James. 1996a. "Home From Nowhere: Zoning Laws' Effects on Quality of Life." *Atlantic Monthly* 278, 3: 43.

Kunstler, James. 1996b. Statement made at Michigan Society of Planning Officials Annual Conference, Lansing, Michigan. Spring.

Ladd, Helen F. 1992. "Population Growth, Density, and the Costs of Providing Public Services." *Urban Studies* 29, 2: 273-96.

Ladd, Helen F., and J. Yinger. 1989. *America's Ailing Cities: Fiscal Health and the Design of Urban Policy.* Baltimore, MD: Johns Hopkins University Press.

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

Lafferty, R. N., and H. E. Frech. 1978. "Community Environment and the Market Value of Single-Family Homes: The Effect of the Dispersion of Land Uses." *Journal of Law and Economics* 21: 380-393.

Landis, John D. 1994. "The California Urban Failures Model: A New Generation of Metropolitan Simulation Models." *Environment and Planning* 21: 399-421.

Landis, John D. 1995. "Improving Land Use Futures: Applying the California Urban Futures Model." *Journal of the American Planning Association* 61, 4 (Autumn): 438–457.

Landis, John D., and David S. Sawicki. 1988. "A Planner's Guide to the *Places Rated Almanac*." *Journal of the American Planning Association* (Summer): 336-346.

Lane Council of Governments 1996. *"Eugene Cost of Growth Analysis",* Eugene Oregon

Lang, Robert E., and Steven P. Hornburg. 1997. "Planning Portland Style: Pitfalls and Possibilities." *Housing Policy Debate* 8, 1 (April): 1-16.

Langdon, Philip. *A Better Place to Live: Reshaping the American Suburb.* 1994. Amherst: University of Massachusetts Press.

Lansing, John B. et. al. 1970. *Planned Residential Environments.* Ann Arbor, MI: Institute for Social Research, University of Michigan.

Ledebur, Larry C., and William R. Barnes. 1992. *Metropolitan Disparities and Economic Growth: City Distress and the Need for a Federal Local Growth Package* Washington DC: National League of Cities. March.

Lee, Douglas B. 1995. *Full-Cost Pricing of Highways.* Washington, DC: U.S. Department of Transportation.

Lee, Douglass B. 1992. “A Market-Oriented Transportation and Land Use System: How Different Would it Be?” Presented at the Privatization and Deregulation in Passenger Transportation in Tampere, Finland.

Lee, Douglass B. 1994. *Full Cost Pricing of Highways*. Cambridge, MA: U.S. Department of Transportation.

Leithe, J. L., T. Muller, J. E. Petersen, and S. Robinson. 1991. *The Economic Benefits of Preserving Community Character: Case Studies.* Chicago, IL: Government Finance Research Center.

Lemann, Nicholas. 1989. “Stressed Out in Suburbia.” *Atlantic Monthly* (November): 34-48.

Leonard, Jonathan S. 1987. “The Interaction of Residential Segregation and Employment Discrimination.” *Journal of Urban Economics* 21: 323-46.

Lessinger, J. 1962. “The Case for Scatteration.” *Journal of the American Institute of Planners* 28, 3: 159-69.

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.

Lincoln Institute of Land Policy (LILP). 1995. *Alternatives to Sprawl.* Cambridge, MA: Lincoln Institute of Land Policy; and Washington, DC: Brookings Institution.

Lisansky, J. 1986. “Farming in an Urban Environment: Agriculture Land Use Conflicts and Right to Farm.” *Human Organization* 45: 363-371.

Listokin, David, and Carole Walker. 1990. *The Subdivision and Site Plan Handbook.* New Brunswick, NJ: Center for Urban Policy Research, Rutgers University.

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

Logan, John, and H. Molotch. 1987. *Urban Fortunes: The Political Economy of Place.* Berkeley, CA: University of California Press.

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.

Lopez, Rigoberto A., Adesoji O. Adelaja, and Margaret S. Andrews. 1988. "The Effects of Suburbanization on Agriculture." *American Journal of Agriculture Economics* 70, 2: 346-58.

Lowry, I. 1988. "Planning for Urban Sprawl." In *Transportation Research Board Special Report 221: Looking Ahead, the Year 2000.* Washington, DC: Transportation Research Board.

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.

Maher, Ian. 1992. "Commuting Calculations." *Journal of the American Planning Association* 58: 386-87.

Maine (State of). 1988. *Comprehensive Growth Management Act.* Augusta, ME.

Mandelker, Daniel R. 1962. *Green Belts and Urban Growth*. Madison, WI: University of Wisconsin Press.

Maryland Office of Planning (MOP). 1997. *What You Need to Know About Smart Growth and Neighborhood Conservation.* Baltimore, MD.

Maryland Office of Planning. 1989. *Environmental and Economic Impacts of Lot Size and Other Development Standards.* Baltimore, MD: Office of State Planning.

Maryland-National Capital Park and Planning Commission and Montgomery County Planning Department. 1989. *Comprehensive Growth Policy Study. A Policy Vision: Centers and Trails.* Silver Spring, MD.

Maslow, Abraham Harold. 1970. *Motivation and Personality.* 2d ed. New York: Harper & Row.

McDonald, John, Charles Orlebeke, Ashish Sen, and Wim Wiewel. 1992. *Real Estate Development and Property Taxes in DuPage County: Final Report.* Project #342. Chicago, IL: University of Illinois, School of Urban Planning and Policy, Center for Urban Economic Development. February.

McHarg, Ian. 1969. *Design With Nature*. Garden City, NY: The Natural History Press.

McHarg, Ian. 1996. *A Quest For Life.* New York, NY: John Wiley and Sons.

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

McMillan, David W., and David M. Chavis. 1986. "Sense of Community: A Definition and Theory." *Journal of Community Psychology* 14, 1: 6-23.

Meck, Stuart. 1996. "Planning Practice." *Planning.* November.

Metro. 1997a. *Draft Alternatives Analysis Findings- Briefing Materials for JPACT, MPAC and the Metro Transportation Planning Committee – Regional Transportation Plan Update,* Transportation Services Department, Portland Oregon.

Metro. 1997b. *Urban Growth Report (Revised Draft)*, Growth Management Services Department, Portland Oregon.

Metro 1997c. *Housing Needs Analysis*, Growth Management Services Department, Portland Oregon.

Metro 1997d. *Regional Framework Plan*, November 1997 (Ordinance 97-715A) Growth Management Services Department, Portland, Oregon.

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

Meyer, J., and J. A. Gomez-Ibanez. 1981. *Autos, Transit, and Cities.* Cambridge, MA: Harvard University Press.

Meyer, John R. and Jose A. Gomez-Ibanez. 1981. *Autos, Transit, and Cities*. Cambridge, Massachusetts: Harvard University Press.

Meyer, S. M. 1992. *Environmentalism and Economic Prosperity: Testing the Environmental Impact Hypothesis.* Cambridge, MA: MIT Press.

Michigan Society of Planning Officials (MSPO). 1995. *Patterns on the Land: Our Choices, Our Future.* Rochester, MI: Michigan Society of Planning Officials.

Middlesex•Somerset•Mercer Regional Council and The Regional Plan Association. 1994. *Redesigning the Suburbs: Turning Sprawl into Centers.* Princeton, NJ.

Middlesex•Somerset•Mercer Regional Planning Board. 1990. *Mixed-Use Development: Traffic and Other Impacts.* Princeton, NJ.

Mieszkowski, Peter, and Edwin S. Mills. 1993. “The Causes of Metropolitan Suburbanization.” *Journal of Economic Perspectives* 7, 3: 135-47.

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

Mills, Edwin S. 1991. *Critique of “Impacts of Development on DuPage County Property Taxes.”* Kellogg Graduate School of Management, Northwestern University. June.

Mills, Edwin S., and Bruce W. Hamilton. 1994. *Urban Economics*. New York: HarperCollins.

Mills, Edwin S., and John F. McDonald. 1992. *Sources of Metropolitan Growth.* New Brunswick, NJ: Center for Urban Policy Research, Rutgers University.

Miness, D., and R. C. Einsweiler. 1992. *Managing Community Growth and Change.* Cambridge, MA: Lincoln Institute of Land Policy.

Mobility for the 21st Century: A Blueprint for the Future. 1996. American Public Transit Association's Mobility for the 21st Century Task Force and Robert L. Olson, Institute for Alternative Futures. October.

Moe, Richard, and Carter Wilke. 1997. *Changing Places: Rebuilding Communities in the Age of Sprawl*. New York: Henry Holt.

Moe, Richard. 1995. In Dwight Young, *Alternatives to Sprawl.* Cambridge, MA: Lincoln Institute of Land Policy; Washington, DC: Brookings Institution; and Washington, DC: National Trust for Historic Preservation: 4.

Moe, Richard. 1996. *Growing Smarter: Fighting Sprawl and Restoring Community in America.* Washington, DC: National Trust for Historic Preservation.

Mofson, Phyliss. 1997. Interview by Robert W. Burchell. Tallahassee, FL: Florida Department of Community Affairs. November 5.

Montgomery County, Maryland. 1989. *Alternative Scenarios: Analysis and Evaluation.*

Moore, Terry, and Paul Thorsnes. 1994. *The Transportation–Land-Use Connection: A Framework for Practical Policy.* Planning Advisory Service Report 448/449. Chicago: American Planning Association.

Muller, Peter O. 1986. "Transportation and Urban Form: Stages in the Spatial Evolution of the American Metropolis." In Susan Hanson, ed., *Geography of Urban Transportation*. New York: Guilford Press.

Myers, Dowell. 1987. "Internal Monitoring of Quality of Life for Economic Development." *Economic Development Quarterly* 1: 238-278.

Myers, Dowell. 1989. "The Ecology of 'Quality of Life' and Urban Growth." In *Understanding Growth Management: Critical Issues and a Research Agenda.* Washington, DC: Urban Land Institute.

Nasar, Jack L., and David A. Julian. 1995. "The Psychological Sense of Community in the Neighborhood." *Journal of the American Planning Association* 61, 2: 178-184.

Nathan, Richard P., and Charles Adams. 1976. "Understanding Central City Hardship." *Political Science Quarterly* 91, 1.

National Agricultural Lands Study. 1981. *America's Agricultural Land Base.* Washington, DC.

National Highway Traffic Safety Commission 1990. *The Economic Cost of Motor Vehicle Crashes*, Washington DC, National Highway Traffic Safety Commission.

National Trust for Historic Preservation. 1993. "Potential Effects of a Mega-Store in Kent County." Report prepared by James Hendry. Washington, DC: National Trust for Historic Preservation.

Nelessen, Anton C. 1994. *Visions for a New American Dream: Process, Principles, and an Ordinance to Plan and Design Small Urban Communities*. Chicago: American Planning Association.

Nelson, Arthur C. 1988. "Development Impact Fees." *Journal of the American Planning Association* 54, 1 (Winter): 3-6.

Nelson, Arthur C. 1992a. "Economic Critique of Prime Farmland Preservation Policies in the United States." *Journal of Rural Studies* 6, 2: 119-42.

Nelson, Arthur C. 1992b. "Preserving Prime Farmland in the Face of Urbanization: Lessons from Oregon." *Journal of the American Planning Association* 58: 471-88.

Nelson, Arthur C., and Thomas W. Sanchez. 1997. "Exurban and Suburban Households: A Departure from Traditional Location Theory." *Journal of Housing Research* 8, 2.

Nelson, Arthur C., William J. Drummond, and David S. Sarvider. 1995. "Exurban Industrialization: Implications for Economic Development Policy." *Economic Development Quarterly* 9, 12.

Nelson, Dick, and Don Shakow 1994. *Applying Least Cost Planning to Puget Sound Regional Transportation – Phase 1 Report,* Seattle Washington, Institute for Transportation and the Environment.

Nelson, Robert H. 1977. *Zoning and Property Rights: An Analysis of the American System of Land-Use Regulation.* Cambridge, MA: MIT Press.

Neuman, Michael. 1991. "Utopia, Dystopia, Diaspora." *Journal of the American Planning Association* 57, 3: 344-347.

New Jersey (State of). 1988. *Statement of Financial Condition of Counties and Municipalities*. Trenton, NJ: Department of Community Affairs.

New Jersey State Planning Commission. 1991. *Communities of Place: The Interim State Development and Redevelopment Plan for the State of New Jersey.* July

New Jersey Transit. 1994. *Planning for Transit-Friendly Land Use: A Handbook for New Jersey Communities.* Newark, NJ: New Jersey Transit.

Newman, Peter and Jeffrey Kenworthy. 1989a. *Cities and Automobile Dependence: An International Sourcebook*. Brookfield, Vermont: Gower Technical.

Newman, Peter W. G., and Jeffrey R. Kenworthy. 1989a. "Gasoline Consumption and Cities: A Comparison of U.S. Cities with a Global Survey." *Journal of the American Planning Association* 55*:* 24-37.

Newman, Peter W. G., and Jeffrey R. Kenworthy. 1991. "Transportation and Urban Form in Thirty-Two of the World's Principal Cities." *Transport Reviews* 11, 3.

Nicholas, James C. 1989. “The Costs of Growth: A Public vs. Private Sector Conflict or a Public/Private Responsibility.” In David Brower, David R. Godschalk, and Douglas R. Porter, eds., *Understanding Growth Management.* Washington, DC: Urban Land Institute.

Nicholas, James C., Arthur C. Nelson, and Julian C. Juergensmeyer. 1991. *A Practitioner’s Guide to Development Impact Fees.* Chicago, IL: Planners Press (APA).

Novaco, Raymond W., Daniel Stokols, and Louis Milanesi. 1990. “Objective and Subjective Dimensions of Travel Impedance as Determinants of Commuting Stress.” *American Journal of Community Psychology* 18, 2: 231-257.

Novaco, Raymond, W., Daniel Stokols, J. Campbell, and J. Stokols. 1979. “Transportation, Stress, and Community Psychology.” *American Journal of Community Psychology* 7: 361-380.

Nowlan, David, and Greg Stewart. 1991. “Downtown Population Growth and Commuting Trips: Recent Experience in Toronto.” *Journal of the American Planning Association* 57: 165-82.

O’Connor, Kevin. 1988. *Suburbia Makes the Central City: A New Interpretation of the City–Suburb Relationship.* Berkeley, CA: Institute of Urban and Regional Development, University of California at Berkeley.

O’Sullivan, Arthur M. 1993. *Urban Economics.* 2d ed. Homewood, IL: Irwin.

Office of Planning and Research (OP&R). 1982. *Paying the Piper: New Ways to Pay for Public Infrastructure in California.* Sacramento, CA. December.

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

Oregon Employment Division 1991. *1990 Oregon Covered Employment and Payrolls*, Salem, Oregon, Oregon Employment Division.

Oregon Employment Division 1996. *1995 Oregon Covered Employment and Payrolls*, Salem, Oregon, Oregon Employment Division.

Oregon Progress Board. 1994. *Oregon Benchmarks: Standards for Measuring Statewide Progress and Institutional Performance*. Report to the 1995 Legislature. Salem, OR: Oregon Progress Board. December.

Orfield, Myron. 1995. *Metropolities: A Regional Agenda for Community and Stability.* Minneapolis-St. Paul: Metropolitan Area Research Fund.

Orlando, Florida. 1981. *Urban Area Growth Management Plan.*

Orski, C. Kenneth. 1992. “Congestion Pricing: Promise and Limitations.” *Transportation Quarterly* 46, 2: 157-67.

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

Parsons Brinckerhoff Quade and Douglas 1996a. *Cost of Travel in Boulder*, Portland Oregon

Parsons Brinckerhoff Quade and Douglas, and ECONorthwest. 1996. *A Framework for Evaluating the Impacts of Alternative Urban Forms.* Washington, DC.

Parsons Brinckerhoff Quade and Douglas. 1993. *The Pedestrian Environment.* Portland, OR: 1000 Friends of Oregon. pp. 30-2.

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.

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.

Parsons Brinckerhoff Quade and Douglas. 1996d. "Transit, Urban Form, and the Built Environment: A Summary of Knowledge." In *Transit and Urban Form*, Vol. 1. Washington DC: Transit Cooperative Research Program, Transportation Research Board. October.

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

Pastore, Ann L., and Kathleen Maguire, eds. 1996. *Sourcebook of Criminal Justice Statistics 1995*. Albany, NY: Hindelang Criminal Justice Research Center, University of Albany.

Peiser, Richard B. 1984. "Does It Pay to Plan Suburban Growth?" *Journal of the American Planning Association* 50: 419-33.

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

Petersen, John. 1992. Statement made at Lincoln Institute for Land Policy Conference. April. Reaffirmed Summer 1996.

Pickrell, Donald H. 1989. "Urban Rail Transit Projects: Forecast vs. Actual Ridership and Costs." *Urban Mass Transportation Administration Report.* United States Department of Transportation. Washington, DC: United States Government Printing Office

Pigou, A. C. 1920. *The Economics of Welfare*. Macmillan.

Pisarski, Alan E. 1987. *Commuting in America: A National Report on Commuting Patterns and Trends.* Westport, CT: Eno Foundation.

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

Pisarski, Alan E. 1992b. *Travel Behavior Issues in the 90s.* Office of Highway Information Management, Federal Highway Admin istration.

Pivo, G. 1990. "The Net of Beads: Suburban Office Development in Six Metropolitan Areas." *Journal of the American Planning Association* 56, 4: 457-69.

Plotkin, Sidney. 1987. *Keep Out: The Struggle for Land Use Control.* Berkeley, CA: University of California Press.

Popenoe, David. 1979. "Urban Sprawl: Some Neglected Sociological Considerations." *Sociology and Social Research* 63, 2: 255-68.

Popper, Frank J. 1981. *The Politics of Land-Use Reform.* Madison, WI: University of Wisconsin Press.

Porter, Douglas R. 1997. *Managing Growth in America's Communities*. New York, NY: Island Press.

Porter, Douglass R. 1989. "The States Are Coming, the States Are Coming." *Urban Land* (September): 16-20.

Porter, Douglass R. ed. 1992. *State and Regional Initiatives for Managing Development: Policy Issues and Practical Concerns*. Washington, DC: Urban Land Institute.

Power, T. M. 1980. *The Economic Value of the Quality of Life.* Boulder, CO: Westview Press.

Precourt, Geoffrey, and Anne Faircloth. 1996. "Best Cities: Where the Living is Easy." *Fortune* (November 11): 126-136.

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.

Pucher, John. 1995. "Budget Cutters—Looking at Wrong Subsidies." *Passenger Transport* 3 (March).

Pucher, John. 1995. "Urban Passenger Transport in the United States and Europe: A Comparative Analysis of Public Policies, Part I. Travel Behavior, Urban Development, and Automobile Use." *Transport Reviews* 15, 2: 99-117.

Pucher, John. 1995. *The Costs of Transit versus the Automobile.* Paper presented at National Trust for Historic Preservation "Costs of Sprawl" Conference. Spring.

Purvis, C. L. 1994. *Changes in Regional Travel Characteristics and Travel Time Budgets in the San Francisco Bay Area: 1960-1990.* Paper presented at the Transportation Research Board 73rd Annual Meeting, Washington, DC. January 9-13.

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

Pushkarev, B., and J. M. Zupan. 1982. "Where Transit Works: Urban Densities for Public Transportation." In H. S. Levinson and R. A. Weant, eds., *Urban Transportation: Perspectives and Prospects.* Westport, CT: Eno Foundation.

Rainier, George 1990. *Understanding Infrastructure: A Guide for Architects and Planners*, New York, John Wiley and Sons,

Ravitch, Diane. 1996. "The Problem of the Schools: A Proposal for Renewal." In Julia Vitullo-Martin, ed., *Breaking Away: The Future of Cities.* New York: Twentieth Century Fund: 77-87.

Ray, J. R., S. E. Polzen, and S. E. Bricka. 1994. *An Assessment of the Potential Saturation in Men's Travel. NPTS Demographic Special Report*. Washington, DC: Office of Highway Information Management, Federal Highway Administration.

Real Estate Research Corporation. 1974a. *The Costs of Urban Sprawl. Detailed Cost Analysis.* Washington, DC: U.S. Government Printing Office.

Real Estate Research Corporation. 1974b. *The Costs of Sprawl: Environmental and Economic Costs of Alternative Residential Development Patterns at the Urban Fringe.* Washington, DC: U.S. Government Printing Office.

Regional Planning Board. 1956. *Urban Sprawl.* Lower Mainland, New Westminster, B.C. April.

Reilly, William K. 1973. *The Use of the Land: A Citizen's Policy Guide to Urban Growth.* Crowell, NY: Rockefeller Brothers Fund,

Resource Management Consultants, Inc. 1989. *Development in Wright County, Minnesota: Cost-Revenue Relationship.* Minneapolis: Resource Management Consultants.

Rice Center for Urban Mobility Research. 1987. *Houston's Major Activity Centers and Worker Travel Behavior.* Houston: Joint Center for Urban Mobility Research.

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.

Richardson, Harry W., and Peter Gordon. 1993. "Market Planning: Oxymoron or Common Sense?" *Journal of the American Planning Association* 59: 347-52.

Richmond, Henry R. 1995. *Regionalism: Chicago as an American Region.* Chicago: John D. and Catherine T. MacArthur Foundation. December 6.

Roback, Jennifer. 1982. "Wages, Rents, and the Quality of Life." *Journal of Political Economy* 90, 6: 1257-1278.

Roback, Jennifer. 1988. "Wages, Rents, and Amenities: Differences Among Workers and Regions." *Economic Inquiry* 26: 23-41.

Robinson, Susan K., ed. 1990. *Financing Growth: Who Benefits? Who Pays? And How Much?* Chicago: Government Finance Officers Association, Government Finance Research Center.

Rockerfeller Brothers Fund. 1973. In William K. Reilly, ed., *The Use of Land: A Citizen's Policy Guide to Urban Growth.* New York: Thomas Y. Crowell Company.

Rosen, Sherwin. 1979. "Wage-Based Indexes of Urban Quality of Life." In Peter Mieszkowski and Mahlon Straszheim, eds., *Current Issues in Urban Economics*. Baltimore: Johns Hopkins University Press.

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.

Rudel, Thomas K. 1989. *Situations and Strategies in American Land-Use Planning.* New York: Cambridge University Press.

Rusk, David. 1995. *Cities without Suburbs.* 2d ed. Washington, DC: Woodrow Wilson Center Press.

Salant, Priscilla, Lisa R. Carley, and Don A. Dillman. 1996. *Estimating the Contribution of Lone Eagles to Metro and Nonmetro In-Migration*. Pullman, WA: Social and Economic Sciences Research Center, Washington State University. 86-19. June.

Savageau, David, and Richard Boyer. 1993. *Places Rated Almanac*. New York: Macmillan Travel.

Savitch, H. V., et al. 1993. "Ties That Bind: Central Cities, Suburbs, and the New Metropolitan Region." *Economic Development Quarterly* 7, 4: 341-57.

Schaeffer, M. H., S. W. Street, J. E. Singer, and S. Baum. 1988. "Effects of Control on Stress Reactions of Commuters." *Journal of Applied Social Psychology* 18: 944-957.

Schafer, Robert. 1975. *Exclusionary Land Use Controls: Conceptual and Empirical Problems in Measuring the Invisible Wall.* Cambridge, MA: Harvard University Press.

Schneider, Mark. 1989. *The Competitive City: The Political Economy of Suburbia.* Pittsburgh: University of Pittsburgh Press.

Schultz, Marilyn S., and Vivian L. Kasen. 1984. *Encyclopedia of Community Planning and Environmental Management.* New York, NY: Facts on File, Inc.

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.

Schwartz, Seymour I., Peter M. Zorn, and David E. Hansen. 1989. “Research Design Issues and Pitfalls in Growth Control Studies.” *Land Economics* 62 (August): 223-33

Sclar, Elliot, and Walter Hook. 1993. “The Importance of Cities to the National Economy.” In Henry G. Cisneros, ed., *Interwoven Destinies: Cities and the Nation.* New York: American Assembly of Columbia University: 1-26.

Seidel, Stephen. 1978. *Housing Costs and Government Regulations.* New Brunswick, NJ: Center for Urban Policy Research, Rutgers University.

Seskin, Samuel N., et al. 1996. *Transit and Urban Form.* Washington, DC: Transit Cooperative Research Program (TCRP Project H-1).

Seyfarth, J. T., and W. A. Bost. 1986. “Teacher Turnover and the Quality of Worklife in Schools: An Empirical Study.” *Journal of Research and Development in Education* 20, 1: 1-6.

Sheppard, Stephen. 1988. “The Qualitative Economics of Development Control.” *Journal of Urban Economics* 24, 3: 310-330.

Sherrod, D., and S. Cohen. 1979. “Density, Personal Control, and Design.” In J. Aiello and A. Buam, eds., *Residential Crowding and Design*. New York: Plenum Press.

Sherwood-Call, Carolyn. 1994. *The 1980s Divergence in Per Capita Personal Incomes: What Does It Tell Us?* San Francisco: Federal Reserve Bank of San Francisco. August.

Shilling, James D., C. F. Sirmans, and Krisandra A. Guidry. 1991. “The Impact of State Land-Use Controls on Residential Land Values.” *Journal of Regional Science* 31, 1: 83-92.

Shore, William B. 1995. “Recentralization: The Single Answer to More than a Dozen United States Problems and a Major Answer to Poverty.” *Journal of the American Planning Association* 61, 4: 496-503.

Siemon, Larsen and Purdy. 1990. *Crossroads: Two Growth Alternatives for Virginia Beach. Virginia Beach (VA) Growth Management Study.* Chicago, Illinois.

Simonds, John. 1978. *Earthscape: A Manual of Environmental Planning and Design.* New York, NY: Von Nostrand Reinhold.

Skogan, W. 1986. “Fear of Crime and Neighborhood Change.” In A. Reiss and M. Torny, eds., *Communities and Crime*. Chicago, IL: University of Chicago Press.

Small, K. 1980. “Energy Scarcity and Urban Development Patterns.” *International Regional Science Review* 5, 2: 97-117.

Soll, Michael, and Fritz Wagner. 1991. “Coping with Growth in a Suburban Town: The Case of Mandeville, Louisiana.” *Small Town* (July-August): 18-24.

Solomon, Arthur P., ed. 1981. *The Prospective City*. Cambridge, MA: MIT Press.

Sorensen, A. Ann, Richard P. Greene, and Karen Russ. 1997. *Farming on the Edge.* American Farmland Trust (AFT), Center for Agriculture in the Environment. DeKalb, IL: Northern Illinois University.

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

Spain, Daphne. 1988. “An Examination of Residential Preferences in the Suburban Era.” *Sociological Focus* 21, 1: 1-8.

Sperling, Daniel. 1995. *Future Drive: Electric Vehicles and Sustainable Transportation.* Washington, DC: Island Press.

Steiner, Bill. 1992. “The Future of Downtowns: Issues to Consider As We Approach 2001.” *Small Town* (November-December).

Steiner, R. L. 1994. *Residential Density and Travel Patterns: A Review of the Literature and Methodological Approach.* Paper presented at 73rd Annual Meeting, Transportation Research Board, Washington, DC.

Sterling Forest Corporation (SFC). 1995. *Draft Generic Environmental Impact Statement for the Sterling Forest Community.* Volume 1 of 6. Tuxedo, NY: SFC.

Sternlieb, George, and Robert W. Burchell. 1977. *Residential Abandonment: The Tenement Landlord Revisited.* New Brunswick, NJ: Center for Urban Policy Research, Rutgers University.

Sternlieb, George, and W. Patrick Beaton. 1972. *The Zone of Emergence: A Case Study of Plainfield, New Jersey.* New Brunswick, NJ: Transaction Books.

Sternlieb, George. 1975. *Housing Development and Municipal Costs.* New Brunswick, NJ: Center for Urban Policy Research, Rutgers University.

Stokols, D., and R. W. Novaco, eds. 1981. *Transportation and Well-Being*. New York: Plenum Press.

Stokols, D., R. W. Novaco, J. Campbell, and J. Stokols. 1978. “Traffic Congestion, Type-A Behavior, and Stress.” *Journal of Applied Psychology* 63: 467-480.

Stone, Kenneth E. 1993. *The Impact of Wal-Mart Stores on Other Businesses and Strategies for Coexisting.* Ames, IA: Iowa State University.

Strategic Goals for the 21st Century. 1996. American Public Transit Association’s Mobility for the 21st Century Task Force, and Robert L. Olson, Institute for Alternative Futures. October.

Taylor, P., and C. Pocock. 1972. “Commuter Travel and Sickness: Absence of London Office Workers.” *British Journal of Preventive and Social Medicine* 26: 165-172.

Taylor, Ruth, and S. Gottfredson. 1986. “Environmental Design, Crime, and Prevention: An Examination of Community Dynamics.” In A. Reiss and M. Torny, eds., *Communities and Crime*. Chicago, IL: University of Chicago Press.

Taylor, Ruth. 1992. “The Economics of Open Space as if People and Wildlife Matter.” *Mountain Country.* Fall.

Thompson, J. Phillip. 1996. “Urban Poverty and Race.” In Julia Vitullo-Martin, ed., *Breaking Away: The Future of Cities.* New York: Twentieth Century Fund:13-32.

Tiebout, Charles M. 1956. “A Pure Theory of Local Expenditures.” *Journal of Political Economy* 64, 1: 416-424.

Tischler & Associates, Inc. 1989. “Analyzing the Fiscal Impact of Development.” *MIS Report* 20, 7. Washington, DC: International City Management Association.

Tischler & Associates, Inc. 1989. “Howard County, Maryland: Development Trends and Their Fiscal Impacts.” Bethesda, MD: Tischler & Associates.

Tischler & Associates, Inc. 1990. *Service Level, Cost and Revenue Assumptions: Evaluation of Development Concepts—Howard County, Maryland.* Bethesda, MD: Tischler & Associates.

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

Tischler, Paul S. 1992. “DuPage County & Economic Development: Good or Bad?” *Journal of the American Planning Association*. July.

Transit Cooperative Research Program. 1995. “An Evaluation of the Relationship between Transit and Urban Form.” *Research Results Digest* 7 (June).

Turque, Bill, and Frank Washington. 1991. “Are Cities Obsolete?” *Newsweek* (September 9): 42-45.

U. S. Department of Commerce. Bureau of the Census. 1980. 1990. *U.S. Census Reports*.

U. S. Department of Transportation, Bureau of Transportation Statistics. 1994. *Transportation Statistics Annual Report 1994.* Washington, DC: U.S. Department of Transportation.

U.S. Department of Commerce. Bureau of the Census. 1982. *U.S. Census of Governments.*

U.S. Department of Housing and Urban Development. 1972. *Total Energy and Pneumatic Waste Collection Demonstrations.* Ref. No. 07-028.

U.S. Department of Housing and Urban Development. 1980. *Metropolitan Development Patterns: What Difference Do They Make?* Washington, DC: U. S. Department of Housing and Urban Development, Office of Policy Development and Research.

U.S. Department of Housing and Urban Development. 1995. *Cityscape: A Journal of Policy Development and Research*. 1, 2. Washington, DC U. S. Department of Housing and Urban Development, Office of Policy Development and Research.

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

Ulrich, R.S., R.F. Simons, B.D. Losito, E. Florito, M.A. Miles, and M. Zelson. 1991. "Stress Recovery During Exposure to Natural and Urban Environments." *Journal of Environmental Psychology* II: 201-230.

Urban Land Institute, National Association of Home Builders, and American Society of Civil Engineers. 1976. *Residential Streets: Objectives, Principles, and Design Considerations.* Washington, DC: Urban Land Institute.

Urban Land Institute. 1963. *Innovations vs. Traditions in Community Development.* Washington, DC: ULI Technical Bulletin No. 47.

US Congress, Office of Technology Assessment 1995. *The Technological Reshaping of Metropolitan America,* OTA-ETI-643, Washington DC.

Van der Ryn, S., and P. Calthorpe. 1993. *Sustainable Communities.* San Francisco: Sierra Club Books.

Vermont League of Cities and Towns and Vermont Natural Resources Council. 1988. "The Tax Base and The Tax Bill." Montpelier, VT: Vermont League of Cities and Towns. September.

Vincent, Mary Jayne, et al. 1994. *NPTS Urban Travel Patterns: 1990 NPTS.* Washington, DC: Office of Highway Information Management, Federal Highway Administration.

VNI Rainbow Appraisal Service. 1992. *Analysis of the Impact of Light Rail Transit on Real Estate Values.* San Diego, CA: MTDB.

Voith, Richard. 1992. "Cities and Suburban Growth: Substitutes or Complements?" *Federal Reserve Bank of Philadelphia Business Review*: (September-October) 21-33.

Voith, Richard. 1993. "Changing Capitalization of CBD-Oriented Transportation Systems: Evidence from Philadelphia, 1970-1988." *Journal of Urban Economics* 33: 361-76.

Voith, Richard. 1996. 'Central City Decline: Regional or Neighborhood Solutions?" *Federal Reserve Bank of Philadelphia Business Review* (March-April): 3-16.

von Reichert, Christiane and Gundars Rudzitis. 1992. "Multinomial Logistical Models Explaining Income Changes of Migrants to High-Amenity Counties." *Review of Regional Studies* 22, 1: 25-42.

Voorhees, M. T. 1991. "The True Costs of the Automobile: A Basis for Comparison." *Grass Roots to Green Modes.* Proceeding*s* of the 12th International Pedestrian Conference, Boulder, CO: 231-6.

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

Wachs, Martin. 1989. "United States Transit Subsidy Policy: In Need of Reform." *Science:* 244.

Webber, Melvin M. 1976. "The BART Experience—What Have We Learned?" *Public Interest* 45.

Webber, Melvin M. 1993. *The Marriage of Autos and Transit: How to Make Transit Popular Again.* Presented to the Fourth International Research Conference, Center for Transportation Studies, University of Minnesota.

Wendell Cox Consultancy. 1996. *Population and Land Area for Urbanized Areas with More Than 1 Million Population in 1990*. www.publicpurpose.com/inf-usua.htm.

Wheaton, William L., and Morton J. Schussheim. 1955. *The Cost of Municipal Services in Residential Areas.* Washington, DC: U.S. Department of Commerce.

Whyte, William H. Jr. 1957. "Urban Sprawl." In *The Exploding Metropolis.* Garden City, NY: Doubleday.

Wiewel, Wim. 1993. "The Fiscal Impact of Commercial Development." *Land Development* (Spring-Summer).

Wilson, William Julius. 1987. *The Truly Disadvantaged: The Inner City, the Underclass, and Public Policy.* Chicago, IL: University of Chicago Press.

Wilson, William Julius. 1996. *When Work Disappears: The World of the New Urban Poor.* New York, NY: Knopf.

Windsor, Duane. 1979. "A Critique of *The Costs of Sprawl*." *Journal of the American Planning Association* 45, 2 (July): 279-92.

Wish, Naomi, and Stephen Eisdorfer. 1996. *The Impact of the Mount Laurel Initiatives: An Analysis of the Characteristics of Applicants and Occupants.* South Orange, NJ: Seton Hall University.

Wohl, Martin. 1976. "The Case for Rapid Transit: Before and After the Fact." *Transportation Alternatives in Southern California.* Los Angeles: University of Southern California, Institute for Public Policy Research, Center for Public Affairs.

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.

Young, Dwight. 1995. *Alternatives to Sprawl*. Cambridge, MA: Lincoln Institute of Land Policy.

Zimmer, B. G. “Metropolitan Development and the Changing Journey to Work.” 1985. *Social Science Quarterly*, 66: 519-532.

Zinam, Oleg. 1989. “Quality of Life, Quality of the Individual, Technology and Economic Development.” *American Journal of Economics and Sociology* 48, 1: 55-68.

Zorn, P. M., D. E. Hansen, and S. I. Schwartz. 1986. “Mitigating the Price Effects of Growth Control: A Case Study of Davis, California.” *Land Economics* 62 (February): 47-57.