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Survey of Land-Use Modeling: An Overview

INTRODUCTION

THIS CHAPTER CONTAINS reviews of six land-use models for five areas: (1) the Puget Sound Regional Transportation Study; (2) the Southeastern Wisconsin Regional Planning Commission Study; (3) the Atlanta Area Transportation Study; (4) the Detroit Regional Transportation and Land Use Study; (5) the Bay Area Simulation Study; and the (6) Bay Area Transportation Commission Study. Each of these models was designed to fit within the framework of a comprehensive study; that is, the models were developed with the broad problems of the area in mind even though they were specifically addressing only a small proportion of the overall problem. It is therefore useful to recognize the comprehensive objectives of the supervising agency.

Detailed individual descriptions of the six models are presented in subsequent chapters.

The goals of the studies, as stated below, are not necessarily those set forth in the enabling legislation or by specific agency directive, but more closely reflect the directions that were actually followed. This is partially so because in several studies the goals evolved while the project was under way.

For the Puget Sound study the major problem was one of developing a transportation network that would satisfy future demands for transportation. A reasonable estimate of future land-use patterns (with minor portions adjustable according to the transport services provided) was therefore required.

Two functional objectives coexisted in the Southeastern Wisconsin study. The short-run objective was the same as that for the Puget Sound study, with the additional purpose of providing information on the demand for schools, sewerage facilities, and housing construction. Scheduling was considered to be important, and therefore a series of incremental forecasts were used rather than a single-horizon forecast. The long-run objective was to develop techniques for producing the specification of land-use plans that would satisfy desirable development objectives and requirements at a minimum cost to the public sector. The costs to the private sector were also considered.

The objective of the Atlanta study was to design a transportation network that simultaneously permitted the solution of current problems and anticipated future requirements. A reasonable forecast of land-use patterns was necessary for estimating future transportation requirements.

The Detroit planners desired time-staged information (i.e., information over time) relating to future requirements for sewerage, schools, and other municipal services, as well as transportation requirements. It was recognized that locational choices by households and businesses would be affected by the supply of these services, which in turn would affect their future demand.

The objectives of the Bay Area Transportation Study (BATS) were to determine the general growth pattern of the region, the relation of land consumption to changes in employment locations, and the impact of several proposed transportation plans. The Bay Area Simulation Study (BASS) had similar objectives. The primary goal of BASS, however, was the development of techniques for studying a large variety of urban problems rather than simply the effects of transportation and employment location changes. Because of the similarity in major objectives and the dissimilarity in approach, we have included both the BATS and the BASS models in our review of land-use modeling for the Bay Area.

The spectrum of purposes is not very broad. However, the relatively small variance in the problems covered has had considerable effect on the modeling efforts. At one extreme, a study directed toward the satisfaction of transportation requirements forecast only the items directly relevant to that subject (i.e., population and industry characteristics directly related to trip-generation equations). At the other extreme, a study to develop a general set of planning tools focused on the complex relationships of industry and population location as a method of expanding knowledge in the field. Between these extremes were studies of other specific problems, such as the demand for schools, which in turn required forecasting the location of households, classified by life cycle, in order to project the number of children in each area.

THE MODELS

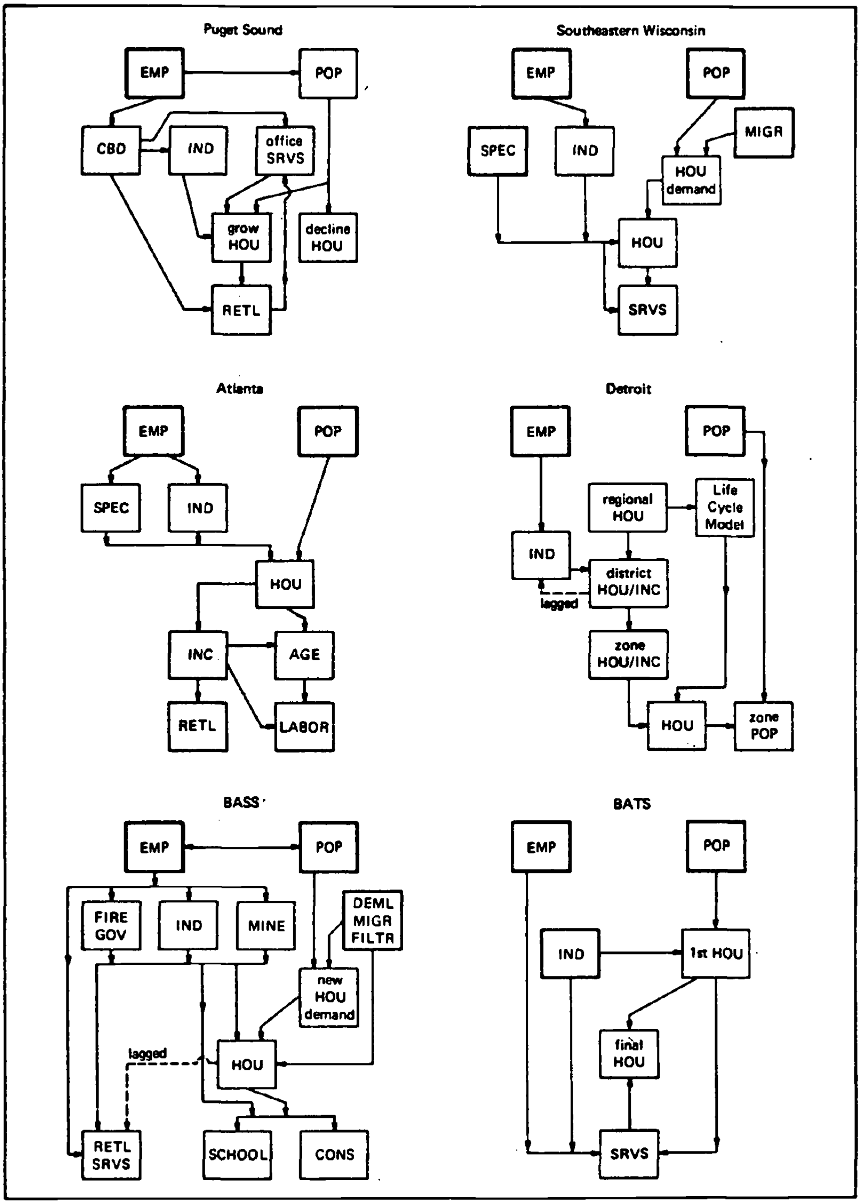
Figure 2 presents the basic structural linkages of the land-use modeling efforts of each study. The common allocation submodels are in the same relative position in each figure. The common framework includes forecasts of employment (EMP) and population (POP), and of the location of groups of industries (IND) and households (HOU). Most studies located retail (RETL) or service industries (SRVS) as separate categories, making them functions of the location of the basic industries and that of households.

In simplified form or schema, the approaches are remarkable for their similarity rather than their differences. Each of the models stresses the importance of industry employment location in determining household location, though they differ in the amount of reliance placed on employment location. In BATS, household location depends entirely on the place of work. By contrast, Southeastern Wisconsin relies more on the demand for particular kinds of housing and assumes that households will look for only a "reasonable" access to employment, retail services, and other households.

Retail employment is generally seen to adjust to household location. However, some approaches do not reflect this. BATS introduces a slight variance by locating retail service employment after the location of only basic employment households. In the cases of Detroit and BASS, retail employment is a function of the population locations in the previous time period, a feature made possible by their recursive approach to the simulation.

Since the location of basic industry is emphasized, it is annoying to find so little effort devoted to understanding the factors affecting the choice of industrial locations. In the extreme, the industries are simply placed where the planners would like them to locate. While this procedure is useful for studying the patterns conditional upon particular industry locations, it seems dubious to predict travel demand when no effort has been made to estimate the likelihood of that particular industry configuration. Even where industry location has been included in the study, the resultant models have not been particularly satisfactory.

Figure 2
Basic Structural Linkages of the Land-Use Models



The figure also suggests the extent to which the models almost exclusively focus on the demand side of the housing market. The exceptions are BASS and Southeastern Wisconsin, which make quite different attempts to incorporate the supply side of the market. Still, it is not far from the mark to suggest that each of these models views the supply side of the market as simply reacting to housing demand.

Tables 1 through 7 below are presented as a cross classification of the techniques and the various submodels of the six models discussed in this paper, with Table 1 suggesting the general techniques used in each. The tables are included to enable the reader to make further comparisons of the similarities and differences among the models.

Tables of Land-Use Models

The purpose of these tables is to present a concise and certainly simplified picture of the overall workings and techniques used in the submodels of the six land-use models reviewed in this report. In Table 1 the submodels for each of the models are cross-classified with the most commonly used procedures or techniques. Tables 2 through 7 present the causality and relationships of the models. In each of these tables, the stub lists the various functions of the model, such as distribution of population, while the column heads at the top of the table list those factors upon which the functions of the model depend. The symbols in the body of these tables also require some explanation: An X indicates that the factor determining the function is exogenous to the land-use model. An E indicates that the determining factor is endogenous to the land-use model.

We have made every attempt to make these descriptions of the models as accurate as possible. Of course, any concise verbal description of analytical models as complex as these is a risky enterprise. We have tried as far as possible to follow the lead of the modelers and made large use of the published descriptions of their models. Our own choice of emphasis, however, will inevitably differ from that which they would have made.

Some aspects of these descriptions are quite technical. In most cases, the technical parts are not crucial for an understanding of the structure of the models. Further, the technical material is not important for understanding the evaluations made in the final chapter.

Table 1
Techniques and Procedures

	Regression	Judgment	Index Ranking	Gravity Access	Proration	Linear Program	Taxo-nomic	Un-specified	Trend
Puget Sound									
CBD employment projections	—	—	—	—	—	—	—	X	—
Employment distribution, non-CBD areas									
Industrial	—	—	—	—	—	—	X	—	X
Retail									
Comparison goods	—	X	—	—	—	—	—	X	X
Convenience goods	—	—	—	—	X	—	—	—	—
Office service	X	—	—	—	—	—	—	—	—
Population distribution									
Growing areas	X	X	—	X	—	—	—	—	—
Declining areas	X	X	—	—	—	—	—	—	—
Southeastern Wisconsin									
Employment distribution									
Manufacturing	—	X	—	—	—	X	X	—	—
Retail	—	—	—	—	X	—	—	—	—
Special	—	X	—	—	—	—	—	—	—
Population distribution	—	—	—	X	—	X	X	—	—
Atlanta									
Industrial employment distribution	—	—	X	—	—	—	X	—	—
Population distribution	—	X	—	—	—	—	—	—	X
Mean family income distribution	—	X	—	—	—	—	X	—	—
Residential densities	—	X	—	—	—	—	—	—	—

(continued)

Table 1 (concluded)

Spatial age distribution	—	—	—	—	—	—	X	—	—
Distribution of labor force participation rates	—	—	—	—	—	—	X	—	—
Retail sales space distribution	—	X	—	—	X	—	—	—	—
Detroit									
Distribution of									
Employment	X	—	—	X	—	—	—	—	X
Households to districts	X	—	—	X	—	—	X	—	—
Households to zones	X	—	—	—	—	—	—	—	—
San Francisco: BASS									
Employment distribution									
Retailing	X	—	X	X	—	—	—	—	—
Manufacturing	X	—	X	—	—	—	X	—	—
Financial and real estate	—	X	—	—	X	—	—	—	X
Services	X	—	—	—	X	—	—	—	—
Construction	—	—	—	—	X	—	—	—	—
Distribution of housing demolition and filtering	—	—	—	—	X	—	—	—	—
Population distribution	—	—	—	X	—	—	—	—	—
San Francisco: BATS									
Distribution of									
Basic industry to counties	X	—	—	—	—	—	—	—	X
Basic industry to zones	X	—	—	—	—	—	—	—	X
Basic industry employment families	—	—	—	X	—	—	—	—	—
Population-serving employment	—	—	—	X	—	—	—	—	—
Population-serving employment families	—	—	—	X	—	—	—	—	—

Table 2
Puget Sound Regional Transportation Study

	Employment Projections		Non-CBD Employment Totals	Land-Use Catalog	Regional Population Projections
	CBD	Regional			
Non-CBD employment totals	X	X	——	——	——
Distribution of non-CBD employment					
Industrial	——	——	X	X	——
Retail					
Comparison goods	X	——	——	——	——
Convenience goods	——	——	——	——	——
Office services	——	——	——	——	——
Population distribution					
Growing areas	——	——	——	X	X
Declining areas	——	——	——	——	——

Table 3
Southeastern Wisconsin Regional Planning Commission

	Regional Projections of		Soil Type Inventory
Distribution of	Employment	Population	
Industrial employment	X	——	X
Population	——	X	X
Special employment	——	——	——
Retail employment	——	——	——

Table 2
(concluded)

Distribution of				Housing Stock Charac-teristics	Trans-portation Measure
Industrial Employment	Population	Comparison Goods	Base-Year Office Services		
—	—	—	—	—	—
—	—	—	—	—	—
—	E	E	—	—	—
—	—	—	—	—	—
—	—	E	X	—	—
E	—	—	—	X	X
—	—	—	—	X	—

Table 3
(concluded)

Regional Design Plan	Distribution of		Transportation Measure
	Industrial Employment	Population	
X	—	—	—
—	E, X	—	X
X	—	—	—
—	—	E	—

Table 4
Atlanta Region Metropolitan Planning Study

	Area Projections			Distribution of		
	Employment	Mean Family Income	Catalog of Land Uses	Industrial Employment	Population	Mean Family Income
Industrial employment distribution	X	——	X	——	——	——
Population distribution	——	——	——	E	——	——
Mean family income distribution	——	X	——	——	E	——
Residential density	——	——	——	——	E	E
Spatial age distribution	——	——	——	——	E	E
Distribution of labor force participation rates	——	——	——	——	E	E
Distribution of retail sales space	——	——	——	——	E	E

Table 5
Detroit Regional Transportation and Land-Use Study

	Regional Projections			Lagged Distribution of	
Distribution of	Employment	Households	Land-Use Catalog	Population	Employment
Employment	X	——	E	E	E
Households to districts	——	X	E	E	E
Households to zones	——	——	E	E	E

Table 4
(concluded)

Spatial Age	Neighborhood Amenities	Housing Stock Assumptions	Tract Socioeconomic Characteristics	Transportation Measure
—	—	—	—	X
—	X	X	—	X
—	—	—	X	—
—	—	—	—	—
—	—	—	—	—
E	—	—	—	—
—	—	—	—	X

Table 5
(concluded)

District Amenities	Socioeconomic Characteristics of Population	Distribution of Households to District	Transportation Measure
—	—	—	X
X	E	—	X
—	E	X	—

Table 6
Bay Area Simulation Study

Distribution of	Regional Projections of: Employment	Regional Projections of: Population	Catalogs of: Land Use	Catalogs of: Housing Stock
Retail employment	X	——	E	——
Manufacturing employment	X	——	E	——
Financial, real estate, and government employment	——	——	——	——
Service employment	X	——	——	——
Demolition and filtering	——	——	E	E
Population	——	X	——	E
Construction employment	——	——	——	——

Table 7
Bay Area Transportation Study

Distribution of	Distribution of Employment: Lagged	Distribution of Employment: Basic to Counties	Distribution of Employment: Basic to Zones	Distribution of Employment: Nonbasic	Land-Use Catalog	Lagged County Rate of Growth
Basic industry						
Counties	E	——	——	——	E	E
Zones	——	E	——	——	E	——
Basic population	——	——	E	——	——	——
Nonbasic employment	——	——	E	——	——	——
Nonbasic population	——	——	——	E	——	——

Table 6
(concluded)

Initial Distributions of		Final Distributions of		
Employment	Population	Population	Employment Excluding Construction	Transportation Measure
E	E	—	—	X
—	—	—	—	X
—	E	—	—	—
E	E	—	—	X
—	—	—	—	—
—	—	—	E	—
—	—	E	E	—

Table 7
(concluded)

Regional Projections		Population Distribution		
Employment	Population	Base Year	Basic	Transportation Measure
X	—	—	—	X
—	—	X	—	X
—	X	—	—	X
X	—	—	E	—
—	X	—	—	X