Chapter Eight: From Monitoring to Simulating Land Capacity at the Parcel Level

Paul Waddell

Land capacity analysis focuses mostly on the attributes of the land and its potential uses. This orientation examines the supply side in detail, while demand remains on such an aggregate level that it only serves to determine a probable time horizon during which the existing capacity will be sufficient for urban development. Hence while land capacity analysis examines in detail vacant or underutilized parcels, the land use plan and zoning that applies to these parcels, and the presence of infrastructure, it has not heretofore done more than acknowledge the existence or relevance of consumer preferences (see Mildner et al., 1996, and chapter 2). Herein lies its largest challenge.

Why are the composition and preferences of urban land consumers potentially so important in this analysis? Because the likelihood of a parcel of land being developed for a particular use and at a particular density is a function consumer preferences. Regulatory frameworks may restrict development options for a parcel to a subset of land uses, and may impose minimum or maximum density limits, environmental constraints, and other land regulations that further restrict development options. Ultimately, though, the specific use of the parcel is driven by the profitability of alternative development outcomes on the parcel, which in turn derive from the tradeoff of development costs and the consumer's willingness to pay for the development.

Three aspects of consumer preferences are salient to this discussion: the composition, or mix, of consumers; consumer preferences for differing types of development; and consumer preferences for different locations, or sub-markets. At the aggregate level, if the composition of consumers changes (e.g., through relatively large inmigration of affluent or poor households), then the demand for certain types of development will grow disproportionately, such as the current growth in demand for large-lot single-family housing, or for condominiums. As for commercial development, different types of businesses have differing needs for development as well, with many factors influencing these choices. Moreover, preferences for different development types and densities may be changing over time. Finally, some of the development options being considered in land use plans call for forms of development about which consumer preferences are not well understood, such as dense urban villages and neo-traditional neighborhood design.

At the sub-market level, different consumer preferences translate into disproportionate demand for housing or nonresidential space in particular geographic areas, on the basis of accessibility to desired amenities and activities. This spatial bias in preferences is perhaps one of the most serious oversights in current land capacity analysis. It explains why certain areas that have substantial land for development remain under-developed, while others that have insufficient land continue to develop, even with rapidly increasing prices. An example of this problem is industrial land supply, which if zoned in the “wrong” places within a metropolitan area, will render the aggregate supply of such space meaningless in terms of its long-term adequacy to accommodate development.

The analysis of the composition and preferences of consumers for different types and locations of development is essential to making reasonable assessments about the adequacy of land supply for a given time horizon. Urban simulation modeling may play a constructive role as a complement to or extension of current land capacity analysis by incorporating the full level of detail in the land inventory, and by simulating consumer preferences and the development process on land parcels. We turn in the next section to a description of the UrbanSim model, as one prototype of such a modeling approach, in order to explore this possibility in more detail.

Urban Simulation Modeling

Recent innovation in the development of operational urban simulation models provides one potential avenue for addressing some of the concerns about land capacity analysis raised in the preceding section and in earlier chapters. The key omission in most land capacity analysis is the detailed analysis of variations in consumer demand for housing by type and location. Urban simulation models such as UrbanSim provide a mechanism to model the demand for alternative types of development at detailed spatial locations, so that the market effects on the consumption of available land can be more effectively considered in refining estimates of land capacity under alternative land policies. The potential application of urban modeling to land capacity analysis is probed in this section by examining the development and application of the UrbanSim model in Eugene-Springfield, Oregon.

The UrbanSim model was developed as a prototype metropolitan land use model for the Oregon Department of Transportation and intended for use by Metropolitan Planning Organizations (MPOs) in the state, in conjunction with the MPO travel demand forecasting models (Waddell, 1999, 1998a, b). The motivation for the model development project was to facilitate land use and transportation planning at the regional level within the context of growth management policies at the state and local level. The initial prototype has been completed, and the design of the second-generation model is underway. The model is now being implemented in Honolulu and Salt Lake City, and a national grant is being used to generalize the model and make it more widely available.[1]

The model can be summarized as a behavioral simulation of the choices made by key actors in the urban development process: households, businesses, developers, and governments. It operates in a quasi-dynamic manner over one-year increments in time, for short to long-term horizons. An abbreviated description of the components of the model relevant to this discussion is presented in the following sections. We treat consumer demand, the land development process, the role of land regulations and transportation infrastructure, and the use of parcel-level data in turn.

The Demand Side

The demand side of UrbanSim simulates consumer preferences of households and businesses by market segment for locations and development types. Households are stratified by income, age of the head of the household, number of persons, and presence of children. Businesses are stratified by industry and number of employees. For different market segments, we estimate the consumer preference for development types and locations by observing the choices made by

[1] Funding for UrbanSim development has come from the Oregon Department of Transportation, the Oahu Metropolitan Planning Agency, the Governor's Office of the State of Utah, and the National Cooperative Highway Research Program 8-32(3) "Integration of Land Use Planning and Multimodal Transportation Planning."

recent movers, and using these consumers to estimate statistically the preferences of a group of consumers.

The prices paid by consumers for the development types at the chosen locations represent consumers' "bids" for these developments. We know that the observed locations of recent movers are the result of their successful bid for the property, meaning that they were the highest bidder for the particular development they now occupy, based on the assumption that land owners sell to the highest bidder. The examination of successful bids of a sample of recent movers, including the prices paid and the characteristics of the development types and locations, forms the foundation for the demand analysis. We label these consumer preference estimates "bid functions." The characteristics considered in the bid functions are those that we anticipate from theory to influence consumption choices, and which we can measure using available data.

The variables considered in the household bid function in the Eugene-Springfield application of UrbanSim include:

- housing types (using single-family residential as the omitted comparison type)
- access to jobs and shopping from the zone
- density, age, and size of the housing stock of each type in the zone
- income mix of residents in the zone and the percentage with children
- land use composition
- travel time to the Central Business District

Note that each of these variables must be updated as part of the simulation; they are endogenously predicted within the model. The variables represent characteristics of housing and location anticipated from urban economics and geography to influence residential location. The bids are for groupings of individual housing units by traffic analysis zone and housing type.

The estimation of the bid function for households of different types yielded results in the Eugene-Springfield application that were reasonable and intuitive as well as statistically significant. The residential bid functions were estimated separately for households stratified by income group and presence of children, generating eight different models. The results of these estimations are discussed in detail in Waddell (1998b), and are summarized here.

The model results explain between roughly 70 and 80 percent of the variation in observed housing prices, indicating that the approach is reasonably robust. This explanatory power is relatively high, considering that the bid estimates are derived from assessed values rather than sales transactions, and that the household data was created from a mixture of census, parcel, and transportation data (Waddell 1998b). These results are indicative of the specification of consumer preference functions that could be useful in relation to assessing land capacity as well.

The results also reveal preferences that differ between household types in interesting ways, such as the relatively lower discounting for density by higher-income households without children, suggesting a potential market segment that would consider dense, in-town housing with substantial amenities. On the other hand, the most affluent households revealed a strong bias toward newer housing, as shown by the strong discounting for housing age. Multi-family and residential 2-4 unit housing types were significantly discounted by all consumer groups as compared to single-family residential development.

This consumer preference framework is extended to predict the successful bidder for each location and development type by using the concept of consumer surplus, defined as the consumer bid minus the market price of an alternative. This theory holds that the probability that a particular consumer will be the highest bidder for a location is proportional to the bidder's consumer surplus. If we take the market price of an alternative as an indication of the highest bid among all consumers, then the likelihood that a particular consumer will be the highest bidder is proportional to the probability that their bid exceeds the bids of all other consumers. This approach solves the simultaneous problem of translating consumer preferences expressed in the bid function into observed location choices, and of assigning individual properties to the highest bidder.

The probability that a particular consumer will make a particular location choice is then a function not only of their preferences and budget constraints, but those of all other consumers as well. This means that as the composition of consumers changes, say toward higher-income households, we can expect the land market to change in predictable ways, with greater demand for the types of alternatives chosen by these consumers, and higher prices resulting for them (holding supply and all other factors constant).

The specification of bid functions for businesses followed similar lines as above, but for the sake of brevity are not discussed here. A more complete description of the model and the results of the Eugene-Springfield application are available elsewhere (Waddell, 1998a; see also http://urbansim.org).

The Supply Side

The supply side of the model attempts to simulate the development activity of private developers. The development model is based on a micro-simulation of the expected profitability from the development or redevelopment of individual land parcels. While the demand side grouped parcels into clusters of the same development type within each zone, the development component treats each parcel individually. This is because the development process, whether on vacant parcels or through redevelopment of already developed parcels, is most understandable, and therefore the most straightforward to model, at the parcel level.

Within each parcel, we maintain in the model an accounting of the characteristics of land parcels, including:

- Acreage
- Land use
- Land value
- Improvement value
- Housing units
- Square footage of nonresidential development
- Age of improvements

These characteristics are updated by simulated new construction and redevelopment activity. In addition, the following characteristics of parcels may be designated by the user through GIS processing and specific values assigned through the user interface to the model:

- Land use plan designation
- Environmental overlays:
  - Wetlands
  - Flood plains

    * Slope
- Urban Growth Boundary
- Development costs

These latter characteristics form the basis for policies that restrict developer options for a particular parcel or alter the profit calculation by affecting development costs. Overlays such as wetlands, flood plains, and high slope areas are integrated with the parcel boundaries using polygon overlay operations in the GIS. These operations actually subdivide parcels that are intersected by an overlay that crosses the parcel, such as a flood plain, creating separate sub-parcel records if a parcel is bisected by such a boundary. An alternative would be to use the centroids of parcels for the overlay, and assign the entire parcel a value of the overlay (e.g., inside or outside the 100-year flood plain), but this approach would lose useful information for large parcels that have some environmentally sensitive land within the parcel.

The Urban Growth Boundary is also overlaid on parcels, as are the metropolitan land use plan designations. These layers provide a basis for the user to interpret the land use plan and UGB policies directly and to apply rules that constrain developer behavior. User-generated rules include, for each land use plan designation, the types of development allowed, and the minimum or maximum densities associated with each development type. In addition, development costs associated with policies, such as development impact fees to extend services, may be assigned to parcels or development types within the user interface.

Building types are classified from the land use classification codes available within the assessor parcel file. In the application of the model to Eugene-Springfield, the land uses were grouped into[2]:

- Residential Single-Family
- Residential 2-4 Unit
- Residential Multi-Family
- Industrial
- Warehouse

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[2] These land use groupings would vary depending on the location and the needs of the analysis. An effort is being made in the application of the model to Salt Lake City, for example, to develop a land use grouping that can be related to New Urbanism development types designed by Peter Calthorpe.

- Retail
- Office
- Special Purpose

Mixed-use categories existed only in the land use plan, but not in the Eugene-Springfield grouping of existing land uses. Given these data limitations, mixed land uses were accommodated in the model within a cluster of parcels rather than within a single parcel.

The actual behavior of the developer model is based on microsimulation of alternative development projects on individual parcels. The model checks the land use plan designation for the parcel, determines which development types are allowed and within what range of density, checks for environmental or UGB constraints, and then develops tentative projects for each allowed option. The expected profitability of each of these tentative projects is estimated, and all of these projects across all parcels are rank-ordered by profitability.

The profit calculation uses the expected revenue from each tentative project, based on the market value of the development type at the location in the previous year, and subtracts the costs of the development. The development costs include the land cost, hard construction costs, soft costs of development (e.g., development impact fees), and for redevelopment situations, includes the cost of existing improvements and the cost of demolishing those improvements.

$$\prod_i (lb) = R_{lb}Q_{ib} - L_i A_i - H_b Q_{ib} - S_{lb}Q_{ib} - I_{ib}Q_{ib} - D_{ib}Q_{ib}$$

where:

$\prod_i (lb)$ is the expected profit from developing parcel i in location l into building type b

$R_{lb}Q_{ib}$ is the expected revenue from selling the project to consumers

$L_i A_i$ is the land cost of parcel i (land cost per acre times acres)

$H_b Q_{ib}$ is the “hard” construction cost of the development project (its replacement cost)

$S_{lb}Q_{ib}$ is the “soft” construction cost of developing the project including development fees

$I_{ib'}Q_{ib'}$ is the cost of existing improvements on parcel i if it is being redeveloped

$D_{ib'}Q_{ib'}$ is the demolition cost for any improvements on parcel i if it is being redeveloped

The expected revenue is based on the current market price for space of building type b in location l:

$$R_{lb} = P_{lb}$$

The quantity of construction, Q_{ib}, is a function of the size of the parcel being evaluated and the density of construction. The density at which new construction occurs is predicted to be responsive to land prices, with higher land prices prompting capital/land substitution by developers. As land prices increase, we would expect developers to build at higher densities[3]. In markets with a supply of vacant land that is low relative to the demand generated by economic growth, vacant land prices should increase, sending an economic signal to developers to increase density. The density on which the expected profit of each development project is computed, then, is:

$$\Phi_{lb} = a_b + b_b \ln(P_{lb})$$

where:

Φ_{lb} is the density for parcels in location l and building type b

P_{lb} is the land price per acre in location l for building type b

Market Price Adjustment

Land market price adjustment is an aspect of the model system that reconciles demand for land from households and business establishments with each other, and with the available supply of developed space in every year. It handles the assignment of moving businesses and households to their best (highest consumer surplus) alternative that is available, and adjusts land prices

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[3] One exception to this expectation is an important one: large-lot luxury single-family housing. Affluent households may bid a premium to retain low density, thereby reversing the general pattern. The degree to which this pattern exists can be determined from the data.

according to the ratio of demand to supply in each zone. Since prices enter the location choice utility functions for businesses and households, an adjustment in prices will alter location preferences in the subsequent year, causing higher price alternatives to become more likely to be chosen by occupants that have lower price elasticity of demand, all else being equal. Similarly, any adjustment in land prices alters the preferences of developers to build new construction by type of space, and the density of the construction.

Once households and businesses have evaluated all the available alternatives and expressed their preferences (through a probability prediction from the location choice models), the simulation attempts to place households and businesses into buildings in proportion to their predicted probabilities. Alternatives that become full during this operation are removed from the remainder of the allocation process, and households and businesses that are unable to locate into their highest utility building are forced to accept their next highest utility alternative. This process iterates until all businesses and households are located.

The market-clearing mechanism, then, is not strictly through a full equilibrium price adjustment, in which perfect information exists, and transaction costs are zero, so that prices for all buildings at each location adjust to the equilibrium solution that clears the market. Rather, the solution is based on an expectation of incomplete information and nontrivial transactions and search costs, so that movers obtain the highest satisfactory location that is available, and prices respond at the end of the year to the balance of demand and supply at each location.

Once the market assignment is completed, the information generated by the market simulation about the relative demand and supply of each building type at each location is used to update prices. The magnitude of the price adjustment is based on current vacancy rates in the zone and region compared to a 'normal' or 'threshold' vacancy rate assumed to be at equilibrium. The adjustment factor is capped at an annual change of no more than a user-specified percentage in either direction.

The supply of housing and commercial space consumed in any iteration comes from existing vacant structures plus any new construction and redevelopment of structures that occurred in the most recent period. New construction in a forecast interval can include committed, proposed, and potential development projects identified by the user as development events.

The form of the price adjustment is:

$$P_{lbt} = P_{lbt-1} \left[\frac{1 + a_b - V_{lbt} + l \; 1 + a_b - V_{bt}}{1 + l} \right]^{b}$$

where

P_{lbt} is the land price of building type b in location l in year t

P_{lbt-1} is the previous year closing land price for the same building and location

V_{lbt} is the current vacancy rate for space in the building type and location l

α_b is the normal vacancy rate for building type b

$\beta$is a scaling parameter for the price adjustment, initially set to 1

? is a parameter for weighting the regional and zonal influence

Since vacant land price is a key determinant of the profitability of alternative development outcomes on each vacant parcel (entering the cost side of the profit equation) the model must update vacant land prices as urban development proceeds and the prices of developed land change around each vacant parcel. We expect that vacant land prices will adjust in relationship to developed land prices in a local area as a result of land speculation. Speculators purchase vacant land and hold the land until the land price increases as the opportunities for developing the land increase with the encroachment of urban land development.

Vacant land prices are adjusted by the weighted average of the price adjustments (in the current year) of each of the developed building types in a location. After the location of businesses and households triggers a market adjustment in land prices for each building type, these price adjustments are applied to the vacant parcels in a zone in proportion to the acreage of land containing each building type.

Database Development

The database developed for the implementation of UrbanSim contains the following elements:

- Parcel GIS database containing approximately 73,000 parcels within the Lane COG planning area.
- Business establishment database for approximately 6,000 businesses within the planning area.
- A household database synthesized from census tabulations by census block group and the 5% Public Use Microdata Sample.
- GIS themes representing land development constraints, including the Urban Growth Boundary, high slopes, wetlands, floodways, stream buffers, and utility line easements.
- Zone to zone travel impedances from the travel demand model, for computing accessibility measures.
- Regional control totals, specifying the overall level of population and employment growth.

The parcel data used in this project originated from the Lane Council of Governments, and was available for 1994 in ArcInfo format. The database contained assessed land and improvement value, land use code, land use plan designation, and lot size. Although it included the number of residential housing units, the database did not originally contain the square footage of nonresidential buildings. Since the model explicitly accounts for the land market components of land, structures, and occupants, the square footage data was critical for the implementation of the model. Without square footage, the basic supply information for the nonresidential components of the model was missing. LCOG had conducted a study in Eugene in 1994 for developing input data for Trip Generation that included inventorying square footage on nonresidential parcels. A supplemental effort was undertaken by LCOG as part of this project to collect comparable data for nonresidential parcels in Springfield and the balance of the planning area.

Other elements of the parcel database that warrant further description include two aspects of its database design. First, ownership parcels were subdivided by LCOG into land use polygons wherever an ownership parcel contained more than one land use. The dilemma created by this design was that although the area and land use of these sub-parcel polygons were known, other available data such as land value, improvement value, and square footage of nonresidential space, were known or collected only at the level of the ownership parcel. This limited our ability to exploit the land use data, and for the purposes of the modeling, the ownership parcel was chosen as the basic unit of data. A second database design issue became prominent in subsequent data analysis: wherever a building or complex of buildings such as a mall crossed parcel boundaries, the building or buildings all were assigned to one of the overlapping parcels. This would not have been a concern if the geocoding of businesses had been entirely consistent with the assignment of buildings to parcels. But as we shall discuss later, businesses were often assigned to the parcels adjacent to the one the building had been assigned to, creating the appearance of one parcel with a vacant building, and an adjacent parcel with a "homeless" business.

The business establishment database maintained by LCOG is based on the State Employment Commission employer database. It has known omissions regarding self-employment and proprietor establishments, and, as in most states, has the additional problem that all of the employment within a multi-establishment business may be reported at the address of the headquarters or of a single administrative office. LCOG has had an exceptional program in place since 1978, however, to obtain and geocode business establishment data biennially, and to allocate headquarters employment to individual establishment locations. In addition, the geocoding procedures at LCOG are based on the use of a Master Address File that links addresses to individual parcels. This meant that address-matching the business establishment records linked them to the land ownership parcels.

To develop a household database geocoded to the level of Traffic Analysis Zone and housing type, census data and parcel data were combined in an innovative synthesis approach. Procedures for imputing or synthesizing household data from combining geographically-detailed census tabulations with sample data such as the 5% Public Use Microdata have been described and used by various researchers in the context of developing microdata for models based on microsimulation (see, for example, Clarke 1996). The techniques involved typically are based on either Iterative Proportional Fitting (IPF) or on reweighting of sample weights in a survey sample. The approach used in this project employed IPF to allocate household samples into census block groups using marginal tabulations by block group, and using parcel data on housing units by type by Traffic Analysis Zone and census block group to assign households to Traffic Analysis Zones.

The resulting database contained households and businesses stratified into groups, and geocoded to combinations of Traffic Analysis Zones and building types. Information on the parcel characteristics of each of these building objects was derived from the parcel database, including the quantity of housing units and nonresidential square footage, land and improvement values, and acreage. A link to the fully disaggregated parcel database is retained both in the initial database and throughout the execution of the UrbanSim model.

Simulating Land Capacity

The model simulates urban development on the basis of scenarios consisting of the land use plan, environmental constraints, density restrictions, development costs, urban growth boundaries, transportation infrastructure (which generates accessibility measures through the travel models), and expectations of aggregate economic growth in the region. The outcomes predicted by the model include:

- Land, housing, and commercial real estate prices
- Quantity of real estate development by type
- Quantity of land developed for each use, and remaining vacant land
- Development density by type of development
- Quantity of development occurring on vacant land and from redevelopment
- Location of businesses and households by type
- Measures of consumer surplus by type of household and business

These would appear to be sufficient measures with which to assess land capacity. The model provides a framework to undertake multiple analyses with scenarios that combine different land use and transportation policies, and evaluate their impact on urban development and on the degree to which the goals of growth management are being achieved.

Refining the Model

Several limitations in the current model implementation are being addressed in planned updates. They include the management of large developments “in the pipeline,” by allowing the user to enter large development events that the model would be unable to predict. A similar issue applies to major business events, such as the recent location of a major semiconductor plant in Eugene.

An additional refinement of the development module relates to the way it simulates development projects on large parcels. Currently, the entire parcel is assumed to develop at once, and is allowed to develop into only one land use. Clearly, this is unrealistic for large parcels, for two reasons. First, large-scale developments may take multiple years to complete construction. The completion may be phased in, as with residential subdivisions or even multi-family residential development, or may be withheld from the market until completion, as with a large office project. Further, the parcel may be subdivided with different uses on sections of the original parcel, or may be developed as mixed use within the same parcel. These are refinements that remain to be implemented in the model.

A common concern raised about the use of parcel data is the difficulty of spatial processing of parcel data in a polygon-based GIS. This also applies to the model. The overlay operations of environmental constraints require substantial processing, and proximity calculations such as the determination of the mix of land uses within ¼ mile of each parcel would be entirely prohibitive. One solution is the use of a grid-cell conversion of the parcel data and other layers, to facilitate efficient spatial processing. To do so without significant loss of data, the cell size for the conversion would need to be smaller than a small-lot residential parcel, or approximately 50 feet on a side. At this resolution, the size of the raster data becomes quite substantial, and other tradeoffs make the benefits less clear. For example, information about the original configuration of the parcel, such as its size and geometry, may be useful in determining the feasibility of alternative development projects. The size and geometry of the original parcel will be lost upon conversion to a grid representation, unless substantial effort is made to retain a linkage between the original parcel data and its raster representation.

Clearly, additional work is needed to address not only some of these logistical questions, but also substantive ones relating to the construction of the model and its validation to observed trends and patterns of development. Perhaps the difficulties of working with parcel-level GIS data may be more readily addressed if its use is leveraged for planning objectives that are in legislative demand, such as the need for land capacity analysis and for urban simulation modeling for growth management.

Concluding Comments

The real test of the potential value of urban modeling is whether it can be made relevant to planning practice. Such practice occurs not just at the metropolitan scale of regional transportation planning, but also at the municipal and neighborhood scale where the land policy decisions embodied in capital improvements plans, comprehensive land use plans, and other land policies are actually made. Although some of these plans may have the relatively long time horizon of 10 to 20 years, they are more frequently updated, and may need monitoring on a short-term, systematic basis to assess compliance with legislative mandates related to growth management objectives.

How might an urban model such as UrbanSim actually be of value in these planning activities? One scenario would be to adapt the model as a general-purpose planning tool that blends the planning functions of developing and revising comprehensive land use plans, reviewing capital improvement programs, and monitoring compliance with growth management mandates. This would entail a synthesis of the functions of land monitoring and land use modeling in a way that has not been previously attempted. It would also require a multi-participant collaboration that engages municipal, county, metropolitan, and potentially state agencies as partners (see chapter 7). Certainly, the potential technical components of an integrated system to support this approach exist, such as longitudinal GIS, internet-distributed databases and applications, and collaborative decision support systems, even though they may not have been previously integrated or applied to such domains as land capacity monitoring or urban simulation modeling.

The technical issues pertaining to networking, distributed databases and applications to make such a vision become real are trivial, however, compared to the political and organizational obstacles that would need to be overcome. Organizational turf, proprietary approaches to data, political fragmentation, insufficient funding, and innumerable other bureaucratic hurdles obscure the path. Nevertheless, perhaps the technology to develop such a collaborative planning system and the political will to overcome bureaucratic impediments to its development now lie within reach.

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Response One

By Nancy Tosta, Director of Forecasting and Growth Strategy
Puget Sound Regional Council

Paul Waddell has written a provocative paper on urban simulation modeling. He rightly describes a model that he has spent several years refining (UrbanSim) and how it might be used to assist in the process of land capacity monitoring. He argues the point that while there is increasing discussion about monitoring land supply and debate about the resolution at which this must be done, including parcel level, there is no similar discussion devoted to assessing the level and composition of demand for urban land. He sees this as a major shortcoming in most of the existing processes to measure capacity. He describes the work he has done to date in developing the demand functions by estimating consumer preferences in choices made in recent moves. He examines a number of variables to generate eight separate "household bid functions" based on stratification's by income group and presence of children. He then goes on to describe how the model makes use of the parcel data to examine the development process. It is the combination of high detail in the land inventory, as well as the ability to simulate consumer preferences and parcel level development that makes the model potentially useful in the process of land capacity monitoring.

There is no argument that the lack of understanding of what consumers are most likely to do diminishes a true understanding of the land supply picture in most land capacity analyses and Waddell's efforts to address this shortcoming are important. However, attempts to model this form of complex behavior require that certain variables be selected and analyzed, while others are ignored. The ones that are ignored are more likely to be those that are difficult to measure, even though they may be more important. For example, while the model takes into account access to employment and travel time to the central business district, access to good schools, or perception of neighborhood crime are not addressed.

An additional challenge in the UrbanSim approach is posed by the requirements for data quality. Waddell outlines the problems related to acquiring accurate parcel data, in that they are often missing appropriate attributes, are seldom available in digital form, the spatials and attributes may not be connected, there may be limitations on data use, and the files may not be kept current. Relatively few jurisdictions in the nation have the depth of experience in GIS that Lane County, Oregon, as the site of the pilot, does. Lane County maintains a large number of accurate data layers, in a jurisdiction with relatively few parcels. The intensity of data development that is required to run the model may impede its usefulness in larger jurisdictions that have not invested in accurate parcel databases. Waddell seems to express concerns of his own about the model at the end of his paper with the statement "Clearly, more work is needed to address some of these logistical questions, as well as substantive ones that relate to the construction of the model and its validation to observed trends and patterns of development." Aside from these practicalities, the scope and thinking in the paper are valuable to consider what might be done someday when we catch up with the capability that technology offers.

Response Two

By Kenneth J. Dueker, Director
Center for Urban Studies, Portland State University

Paul Waddell's paper on the UrbanSim model identifies several issues that I would like to address as well. First, the paper identifies and explores a range of approaches to assessing land supply. The author stresses the importance of the demand side in land monitoring, expressed as the composition of urban land consumers and their preferences for development types and locations. UrbanSim attempts to incorporate the behavioral foundation of key actors—households, businesses, developers, and governments—in simulating land use change. The structure of the model is a nested locational choice model, incorporating temporal dynamics and using lag variables. My remarks focus on the interplay of modeling, data issues, and behavioral choices.

The UrbanSim model is an important contribution. It is comprehensive and has a logical theoretical structure. As the author describes, past approaches to land monitoring do not connect the supply and demand sides very well; they tend to concentrate on one side to the exclusion of the other. Land capacity studies tend to be driven by the inventory of developable lands with inadequate distinction of demand differences. Similarly, land use models are demand-driven allocations of regional forecasts of population and employment to small areas using highway accessibility as a driver, with land capacity as a constraint to insure that too much demand was not allocated to zones that were built out.

UrbanSim is a robust model of both the demand and supply sides at a low level of aggregation. Specifically, the parcel is important. The model utilizes parcel data appropriately by relating parcels to polygons representing physical and land policy limitations to development. On the demand side, parcel data are aggregated to traffic analysis zones to relate prices as represented by aggregated assessed values to accessibility, neighborhood effects, household socio-economics, and density, as measured at the zonal level.

In simulating consumer preferences of households and businesses UrbanSim uses assessed value aggregated by transportation analysis zones (TAZs) and housing types as the dependent variable in the household bid function, rather than sales price at the parcel level. This is an appropriate compromise given limitations in market data and modeling capabilities.

The supply-side of the model operates at the parcel level, and physical limitations to development and planning restrictions are applied to parcels. Then the expected profitability of all parcels are rank-ordered. Tradeoffs between using polygons or 50-foot grid cells are discussed in terms of efficient spatial process, and incorporating physical limitations and planning zones.

The UrbanSim data units – polygons, parcels and zones—are an adequate abstraction of the real world for the purposes of a data model for land monitoring. The modeling and data choices made in developing UrbanSim avoid difficult problems of dealing with individual buildings, building permits, individual businesses and households, and tracking their changes. UrbanSim demonstrates the power of abstracting and choosing well the units of analysis and the data.

In closing, I would like to commend this effort, not only for its technical contribution, but because a good land use model is really needed. Too many long-term planning efforts are based on political or "wishful thinking" allocations of population and employment. As the "New Urbanism" dominates planning efforts and calls for higher densities, more mixed use, more redevelopment, and less fringe area development than the market would normally provide, models like UrbanSim can be used to test these concepts and policies before committing to their implementation. UrbanSim holds the promise of more realistic and accurate conditional forecasts of the future location of population and employment upon which to base plans.

Excerpts From Seminar Discussion

- In the residential choice model had you considered schools and crime as potential variables? Household age?

  Schools and crime are not in the model because they are not variables that are predicted by the model—these may be prohibitively difficult to predict in the same manner that changes in the other variables are predicted by the dynamics of UrbanSim. Additionally, there are limitations to the data and complexities inherent in their measurement that would hinder their conversion to easily quantified variables.

  The age of housing effect is non-linear. This can be dealt with either by dealing with it as a continuous variable or by assigning dummy variables for housing of different age brackets.