Land Supply and Infrastructure Capacity Monitoring for Smart Urban Growth

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Abstract

The fundamental debate about urban growth—No growth, slow growth, go growth?—will never be resolved. As with politics and religion, all are entitled to their opinions, most of which derive more from deeply held beliefs than quickly calculated betas. As with politics and religion, there is something like agreement among a majority of people on very general principles (e.g., civilized life in the 20th century requires some form of government; there are benefits to some type of spiritual relationship with the universe), but that agreement disintegrates when one gets to the specifics (e.g., socialism or capitalism, Republican or Democrat, deist or agnostic, Christian or Moslem).

For urban growth there is a general agreement that it will occur, that it needs some type of management, and that such management requires (at least in part) public policies. The disagreements about growth management are about how many and which policies to use, and how extensively to apply them. Growth management, however, has some measurable dimensions not available in metaphysics. The type, location, amount, and rate of urban growth can all be measured; so can other factors that are correlated with and perhaps cause urban growth. This paper is motivated by the belief that such measures can be assembled, monitored, and analyzed to gain a better understanding of urban growth processes and growth management policy.

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For urban growth there is a general agreement that it will occur, that it needs some type of management, and that such management requires (at least in part) public policies. The disagreements about growth management are about how many and which policies to use, and how extensively to apply them. Growth management, however, has some measurable dimensions not available in metaphysics. The type, location, amount, and rate of urban growth can all be measured; so can other factors that are correlated with and perhaps cause urban growth. This paper is motivated by the belief that such measures can be assembled, monitored, and analyzed to gain a better understanding of urban growth processes and growth management policy.

As for many public policy issues, interest in growth management moves in cycles. Almost a decade of economic growth and associated land development have provided both the increases in economic well-being and the negative impacts on some aspects of quality of life that allow and compel people to think about growing differently or less. Several indicators suggest that growth management is ascendant: the volume of professional literature on the topic, the number of local growth management initiatives, the increase in state and regional planning tools. Prominent national initiatives include smart growth projects at the U.S. Environmental Protection Agency, the Urban Land Institute, and the American Planning Association.

With each cycle the words may get spun (from growth control, to growth management, to smart growth) in an attempt to revitalize the old debate, but the issues and principles remain the same. Key principles of smart urban growth include the prevention of urban sprawl,[1] the integration of transportation and land use plans, the provision of affordable housing, the protection of open space, and the timely and efficient provision of urban infrastructure (APA 1998). Done right, smart growth policies can visibly increase the quality of urban life; done wrong, they can increase land and housing prices and stifle urban growth. Thus, a central problem in growing smart is how to accommodate market forces while preventing the spoil of sprawl. Progress toward resolving this problem, however, can only be made with sound and current information about the supply of and demand for land.

The need for planners to have good information on urban land markets has been recognized for years (Segoe 1941). Three recent changes in planning practice suggest that better information on land and housing markets can and should be obtained and maintained. The first type of change concerns the extent to which land use plans influence the urban development process. In the past, many plans were based primarily on land market trends and designed to accommodate market forces. But increasingly, plans are designed explicitly to alter market forces and are reinforced with binding regulatory controls. The potential influence of plans on land supplies and demands has increased.

The second change derives from advancements in planning technologies. In the past, land use inventories and assessments were labor intensive, costly, and conducted only every 10 to 20 years. Today, with advancements in geographic information systems (GIS), computerized tax assessment records, and integrated land information systems, it is possible to maintain perpetual inventories of land uses, land values, and infrastructure capacities. It is thus now feasible to monitor land supplies and land market activities in a near-continuous fashion.

The third change is in the requirements of state governments, especially those with modern growth management programs. Several programs now require local governments to monitor the supply of developable land, in some cases with specific requirements concerning what must be monitored and how monitoring must take place (APA 1997).

This paper provides an overview of the state of the art and practice of land supply and infrastructure capacity monitoring. It contains five sections:

- An Inventory Interpretation of Land Use Planning and Growth Management
- The Supply of Developable Land
- The Demand for Urban Development
- Monitoring Urban Land Markets
- The Potential of Monitoring for Smart Urban Growth

Each section addresses a set of pertinent topics, but no topic is addressed comprehensively. Our intent is to provide a foundation for further analysis in subsequent, more comprehensive papers.

An Inventory Interpretation of Land Use Planning and Growth Management

We propose that certain aspects of land use planning and urban growth management can be viewed as a problem in inventory management. Sipper and Bulfin (1997, p. 206) define inventory as "A quantity of commodity in the control of an enterprise, held for some future demand." Key questions in inventory management include how much commodity lies in the inventory, when to augment the inventory, and by how much.

Many key questions in land use planning and management sound like questions about inventory:

- How much land and infrastructure is currently available for urban development?
- When must the supply of land and infrastructure be augmented?
- How much land and infrastructure must be provided to accommodate future urban development?

We do not argue that all issues in urban planning and management can be reduced to these questions. We argue instead that an inventory interpretation of these questions yields some insights into the problem of urban planning and management and serves as a framework for evaluating the role of land and infrastructure capacity monitoring.

The traditional approach to land use planning and management, as prescribed by Kaiser et al (1995), involves three steps:

- Identify current land and infrastructure capacity available for urban development;
- Forecast the need for urban development for a period of 10 to 20 years
- Provide ample supply of land and infrastructure capacity to meet anticipated needs.

In recent years two policy instruments have been incorporated into this general planning approach. The first, urban growth boundaries (UGBs), prohibits development from occurring outside the area planned for development. The second, concurrency requirements, prohibits urban development from taking place unless adequate infrastructure capacity is in place. Both policies can be interpreted as regulatory instruments used to implement the traditional planning approach. That is, UGBs constrain urban development to the areas within UGBs and concurrency requirements constrain development within urban service areas, where both areas are determined through the planning process described above.

For ease of exposition, we use the language of UGBs below to apply some general principles of inventory management to the problem of urban growth management. We return to differences between the approaches in the final section of the paper.

UGBs as a Fixed-Interval System of Inventory Control

The use of UGBs, while not common, is growing. As of this writing, UGBs have been required or authorized for use as a means of controlling urban growth by six states.[2] Statutory requirements for the implementation of UGBs in Oregon are exemplary:

> UGBs shall be drawn around all urban areas in the state…and separate urban from nonurban use.…UGBs shall contain enough land to accommodate growth for a 20-year period….UGBs shall be reexamined every 5 years….Growth projections shall be based on the last 5 years rate of growth.…[3]

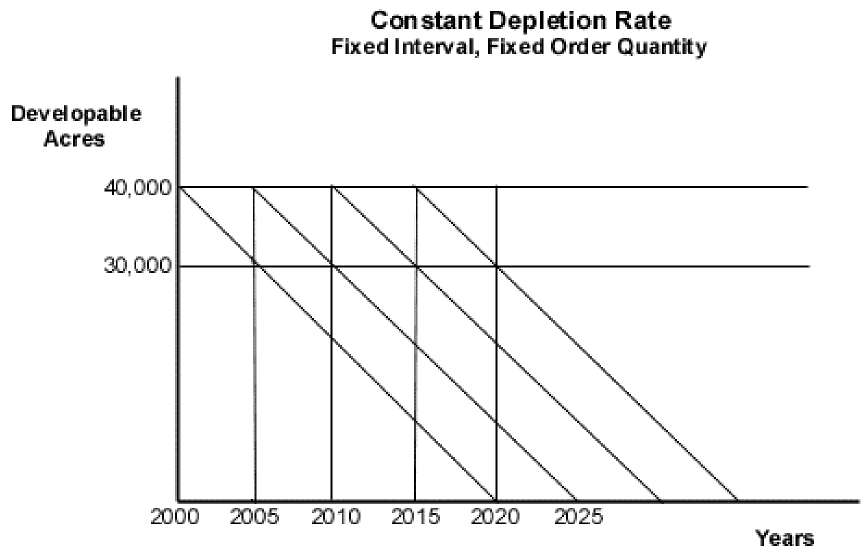
In the language of inventory control, the Oregon statutory requirements that guide the use of UGBs prescribe a fixed-interval system of inventory control: one in which inventory adjustments are made at predetermined dates (Magee and Boodman,1967). In the Oregon system, UGBs encompass the inventory of urban land, measured in acres. The inventory of developable urban acres equals the inventory of all urban acres minus both previously developed urban acres and vacant acres that are not deemed developable (for example, because of natural constraints).

By statute, in Oregon, the inventory of developable land must be sufficient to accommodate 20 years of urban growth at the time the UGB is drawn and expanded, if necessary, every five years. If, for example, the expected rate of urban growth is 2,000 acres per year, then the amount of developable urban acres needed for a 20-year period is 40,000 acres. If the rate of annual growth was constant, then the number of acres needed every five years is 10,000 acres. In the language of inventory control, this rate is called the *replenishment rate* or *order size*, and five years is the *fixed interval* over which inventory is reevaluated and adjusted.

Figure 1 illustrates this type of inventory problem. The inventory of developable acres is depicted on the vertical axis and time on the horizontal axis. If the planning process begins in the year 2000, then the number of developable acres inside the UGB in that year equals 40,000 acres and declines along the first diagonal by 2,000 acres per year. In year 2005, when inventory is again examined, the UGB must be expanded to include another 10,000 acres so that the UGB again contains a 20-year supply. Similar expansions must occur in years 2010, 2015, and 2020. Note that under these conditions, the supply of developable acres never falls below 30,000 acres, or 15 years of supply. This represents the expected minimum stock of inventory—that is, the level of inventory below which the stock is not expected to fall. By implication, that is the stock that is "just right": tight enough to manage growth, but not so tight that it causes unacceptable increases in the price of land.[4]

If the rate of urban development is not constant, but varies from year to year, then the pattern of inventory balance might look more like Figure 2, where the replenishment rate varies as a reflection of the previous five years of growth, and the minimum inventory of developable acres varies according to whether growth was greater or less than the previous five years. The minimum inventory thus varies from year to year but its expected value is constant and determined by the length of the interval between UGB expansions and the expected rate of urban growth.

Figure 1



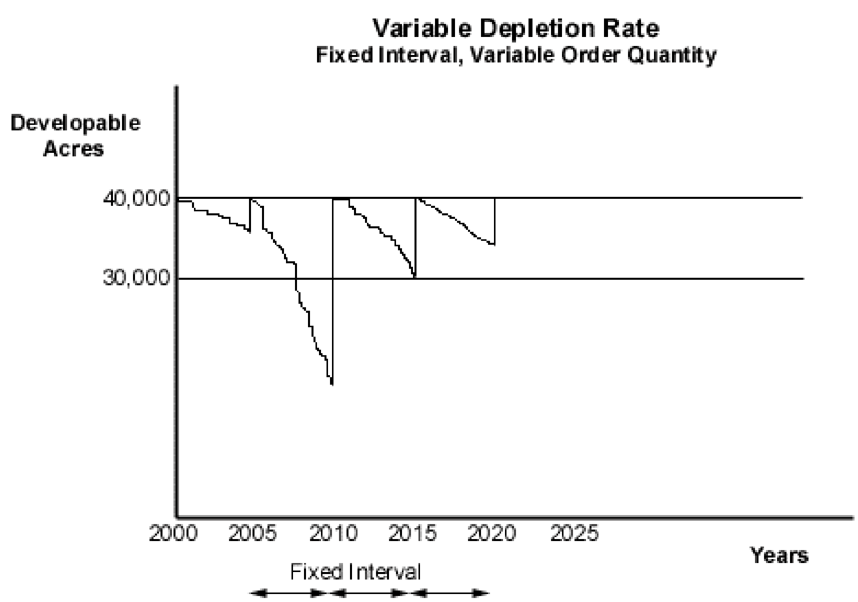
Implementing an UGB based on a fixed-interval system of inventory control, as described above, has a number of advantages. First, the inventory of developable acres need not be continuously monitored but only examined periodically. Because continuous monitoring of urban development has until recently been prohibitively costly, it is not surprising that the fixed-interval approach has been the conventional approach to land use planning. Second, the size of UGB expansion can be based on the most recent rates of urban growth. Thus, excess demands or supplies of urban land can be easily offset in the next planning interval.

But there are limitations as well. First, basing UGB expansion on recent rates of urban growth can lead to overreaction when recent rates are not indicative of long-term trends. It is quite possible that a short-term rise in the urban growth rate can lead to an excessively large expansion of the UGB if rapid urban growth is not sustained. The opposite, of course, is also possible. Second, a fixed-interval system tends to obscure implicit decision variables that are explicit in fixed-quantity systems of inventory control. These decision variables include the order size and the minimum level of inventory.[5]

UGBs as a Fixed-Quantity System of Inventory Control

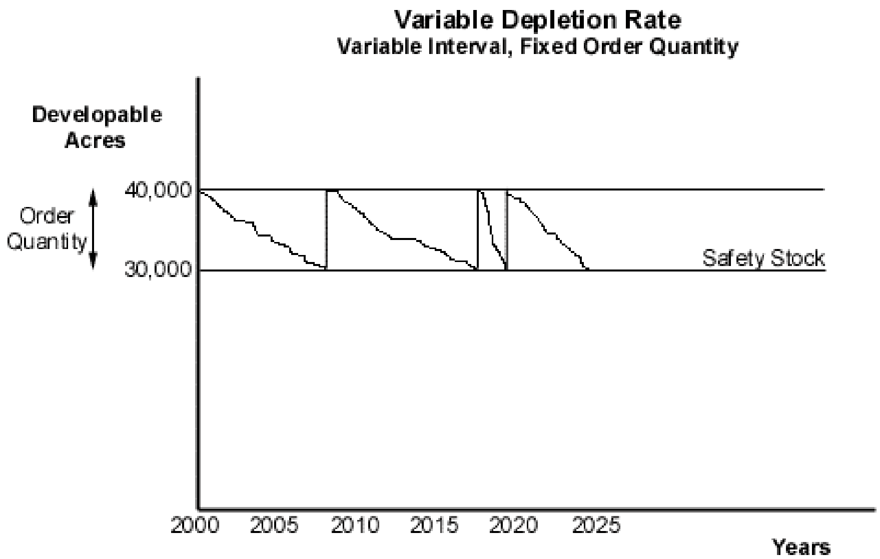
Urban growth boundaries based on fixed-quantity systems (also called fixed-order systems) of inventory control are similar to those based on fixed-interval systems with one exception: they are not expanded at predetermined dates but are expanded by a fixed quantity of acres when the number of acres inside the UGB reaches a predetermined level. If there is no variation in the urban growth rate, then under similar conditions, the pattern of inventory over time would look exactly the same under fixed-interval and fixed-quantity systems (e.g., Figure 1). If the rate of urban growth varies, however, the inventory of developable land inside the UGB under a fixed-quantity system would look more like Figure 3 than Figure 2. In Figure 3, the minimum level of inventory inside the UGB and the size of the UGB expansions remain constant but the length of the intervals between UGB expansions vary with the rate of urban growth.

Figure 2



Like fixed-interval systems, fixed-quantity systems have advantages and disadvantages. Because UGB expansion occurs when the number of developable acres reaches a predetermined level, the inventory of developable acres inside the UGB must be monitored continuously. Further, the dates at which expansion will occur are never known with precision. In a fixed-quantity system, however, the inventory of developable acres never falls below a predetermined level, and the order size and minimum level of inventory can be analyzed directly.

Figure 3



Recent advances in land information systems have made fixed-quantity systems, where UGBs are expanded when indicators reach some critical threshold, a viable approach to urban growth management. For example, UGBs might work as well or better if expansions were conditional on the supply—or the price—of land reaching some critical value. Such a system, once adopted, might take some or much of the political maneuvering, costs, and opportunities for creative compromise out of UGB expansions.

There is much empirical knowledge to be gained by monitoring and analyzing the relationship between the supply and the price of developable land. Decisions regarding the supply of land, like monetary policy decisions about the supply of money, should probably be made after careful review of a variety of price, inventory, and market activity data. Perhaps some hybrid form of inventory control is best.[6] Ultimately, whether it is better to fix the interval between UGB expansions, to fix the size of UGB expansions, or to fix neither the size nor the interval, is an empirical question whose optimal answer depends on the accuracy of urban development forecasts, the cost of continuous monitoring, and the extent to which monitoring can be used to guide UGB expansion decisions.

In the following sections we examine the tasks of identifying developable land, forecasting the demand for urban development, and monitoring land and housing market activity. Our examination is based on planning literature and current practice. For the former, we draw heavily from Kaiser et al (1995) and for the latter we draw from work in Oregon by Metro (the regional government for the Portland, Oregon, metropolitan area), and by ECONorthwest, an Oregon-based consulting firm. Our reliance on practice in Oregon is based in part on our observation that Oregon statutes have forced local governments to pioneer work in this area and in part on our familiarity with practice in that state.

The Supply of Developable Land

All urban planning and monitoring systems must start with an initial inventory of land by type (e.g., vacant or developed; if vacant, developable or constrained; if constrained, relatively or absolutely; if developed, totally unavailable, partially unavailable, or redevelopable). The steps involved in conducting such an inventory are generally understood and accepted (Kaiser et al 1995). They include:

- Identifying vacant land and those lands that cannot be developed due to environmental constraints.
- Subtracting land needed for urban public services.
- Adding land that can be redeveloped or developed at greater intensity though infill.
- Identifying serviced land.
- Estimating development capacity.

The logic of these steps may make them seem simple. In fact, complex technical and conceptual difficulties arise at each step.

Identifying Vacant Land

Vacant land can be identified in a variety of ways: through field inspection, tax assessment records, and remote sensing (Kaiser et al 1995). All have significant limitations.

Field inspections, for all but the smallest of urban areas, are prohibitively expensive. Sampling could reduce the cost, but leads then to either only summary measures or a synthetic database, both of which have their own problems if one is trying to monitor supply accurately.

Summing the areas of parcels classified as vacant in assessor's records is perhaps the least costly method of describing the land inventory. Such simple aggregation, however, can lead to gross errors. Often, the parcel size and use designation in the assessor's files are wrong. Further, the assessor will generally classify a parcel as vacant only the if the parcel is completely vacant. A ten-acre parcel, for example, with a single-family structure may be classified as developed even if local zoning allows for six units per acre. Thus alternative methods must be used to identify parcels that are partially vacant. Moreover, “tax lots” are not necessarily the same as “developable parcels,” which are often aggregations or several tax lots.

Interpretation of remotely sensed data, such as aerial photographs, is an increasingly popular approach, especially for rural areas. Constraints imposed by the resolution of the images, however, continue to limit its use in urban areas. Remote sensing allows a clear distinction between vacant and developed parcels, but a determination of development type or the extent of constraints on developed land is more difficult (Keikkonen and Varfis 1998, Kent, Jones, and Weaver 1993)

In practice, a combination of methods is probably optimal. Metro, for example, uses air photo interpretation in combination with tax-lot maps and information about land characteristics and public utilities, all registered to common coordinates through GIS, to identify parcels that are fully vacant and those that are partially vacant. Even with this approach, however, specific rules must be adopted concerning how large the vacant segment of a partially developed parcel must be in order to classify that part as vacant land (Metro 1997b), and field inspection (either random or systematic) must be used to clean the data base.

Identifying Environmental Constraints

Not all vacant land is developable. It may be constrained either partially or absolutely by a combination of factors.

Almost all land is developable given enough demand, enough money, and the absence of absolute policy restrictions. Even land covered with water can be developed: for example, the San Francisco Bay Area has created land by filling parts of the Bay. Other developments float on the Bay. Thus, dividing vacant land into two mutually exclusive categories of “buildable (developable)” and “unbuildable (nondevelopable)” is a judgment call informed by a simultaneous consideration of land characteristics, market economics, and public policy. It is only when policy gets laid over measurable environmental conditions that a constraint becomes absolute.

For example, where land characteristics are such that any typical development is judged as likely to cause unacceptable environmental damage, such development is either precluded or conditioned. In practice, land is usually considered not buildable if it is located in a floodplain, sloped more than some amount (usually 15 to 25 percent, depending on the use), in a wetland or riparian buffer, or particularly subject to natural hazards such as earthquakes, mud slides, or storm damage (Metro 1997a, ECONorthwest 1998).[7] The most significant change in this type of land analysis, since the writings of Ian McCarg (1971) over 25 years ago, is the addition of GIS, which allows the resource overlay maps to be built and analyzed electronically.

Identifying Potential for Redevelopment and Infill

Growth—the development of infrastructure and structures—is not limited to vacant, buildable land. Growth can occur on land that is already developed through infill (adding more development on unused remainders of developed land) or redevelopment (replacing existing development with new development).[8]

Interest in urban infill and redevelopment has grown rapidly in the 1990s. The development of vacant land at the urban periphery (i.e., suburban development, now often referred to as greenfield development) has been the dominant means of accommodating urban growth. Now redevelopment of blighted urban land (or brownfields) has become perhaps the most salient feature of smart growth strategies. Techniques for estimating how much growth can be accommodated through such mechanisms, however, are only now being developed. Consistent empirical work on rates of redevelopment, parameters essential to forecasting land consumption, is very limited.

Economic theory suggests that redevelopment will take place when the increase in value from redevelopment exceeds redevelopment costs. Recent research by urban economists provide corroborating evidence (Rosenthal and Helsley 1994, Munneke 1996) Thus, with adequate data on parcel characteristics, it would appear possible to develop models that could identify those parcels with the greatest potential for redevelopment.

In practice, however, redevelopment potential is gauged largely using data on assessed improvement and land values. For parcels less than one acre, for example, Metro (1996) compared improvement values to the improvement values of surrounding properties. Metro considered properties redevelopable if the improvement value of the parcel was 50 to 70 percent of the mean improvement value of surrounding properties. ECONorthwest (1998) arrayed all developed land in a matrix with the ratio of improvement to land value on one axis, and parcel size on the other, and then made judgments based on plan designation about the percentage of land in each category that might redevelop over a 20-year horizon.

To estimate infill potential, Metro determined the percent of building permits that had been issued over the last five years to parcels not included in the vacant land coverage. These permits Metro classified as “refill.” Based on this method, Metro estimated that about 25 percent of future housing units could be accommodated on land currently classified as developed (Metro 1999b). Though Metro’s approach seems reasonable, it is not clear that past rates of refill are a good indicator of future development patterns, especially as the capacity to accommodate infill and redevelopment becomes exhausted. Further, Metro’s approach mixes the concepts of refill capacity with a refill forecast.[9]

Identifying Serviced Land

Although managing the supply of developable land is a major component of urban growth management, municipal ordinances often prohibit the development of land without the adequate provision of urban services. For land to be developable it not only it must be vacant and unconstrained by physical factors or policy, but must also be provided with urban services. The literature on how to identify such land, however, is thin.

Identifying the supply of land with access to services requires the articulation of service standards and the attribution of service capacity to land area. The articulation of service standards is necessary to implement any type of concurrency policy. Florida administrative code, for example, requires local governments to establish service standards for roads, sanitary sewer, solid waste, drainage, potable water, parks and recreation, mass transit, and public transit (FAC 9J-5.0055(2)(a)). Level of service standards vary extensively in degree of complexity, but all represent some ratio of the demand for service to the capacity of service available.

The attribution of service to land area is equally complex and varies by type of service (Frank and Falconer 1990). The general service area of an elementary school or fire station, for example, where the level of service depends significantly on spatial accessibility, is round if transportation costs are uniform through space (which is only approximately true even without hills and water bodies). The service areas of roads and sewer systems, however, are far more complex and depend on the route network, spatial chaining of capacity, and temporal dimensions of demand (Frank and Falconer 1990).

In practice the problem has been addressed in a number of different ways. Montgomery County, Maryland, has an extensive planning information system designed to implement its adequate public services ordinance. The County is divided into policy areas and service capacities are monitored for each. When the capacity of a given service reaches a critically low level in the policy area, development can be delayed until sufficient service capacity is provided (Godschalk and Baxter 1998, Levenson 1997). Similar procedures are used in many Florida jurisdictions (White 1996). In Oregon, where growth management policies require an adequate supply of buildable (but not serviced) land, the supply of urban services is treated in various ways. Metro's recent analysis of lands available for future UGB expansions (1998) identified the cost of providing services to various locations when considering how much and where to expand the UGB. Lower-cost locations were ranked as stronger candidates for expansion.

Identifying Development Capacity

Once the net supply of serviced land has been determined it is necessary to identify how much development capacity the land provides. Definitions of development capacity vary. Development capacity, for example, can be based on the capacity of ecological or public facility systems. Examples provided by Kaiser et al (1995) include those based on the evacuation capacity of a causeway in Sanibel, Florida, and the pollution-assimilation capacity of Lake Tahoe. As those examples make clear, however, the carrying capacity of natural and man-made systems are often not fixed but can be increased through infrastructure investments.[10]

In situations where development capacity is not clearly constrained by natural systems, a first step in estimating capacity involves identifying land needed for urban infrastructure, where infrastructure includes streets, water and waste water facilities, schools, parks, churches, and other public and semi-public facilities. Net developable land is the land that is available for development after subtracting land needed for these forms of infrastructure. Estimating land needed for infrastructure can be done using simple or complex methods. Simple methods involve the application of simple ratios, e.g., 15 acres of parkland per 1000 estimated population growth, or 25 percent of developed land for streets (Harris 1992). More complex methods take into account the size and configuration of parcels, the age distribution of the population, and the existing capacity of public and semi-public facilities (Metro 1997a).

After netting out land needed for infrastructure, development capacity is typically estimated by type of land use using a technique called build-out analysis (Knaap 1998a). For residential development, the standard approach is to disaggregate land supply by zoning (or plan designation) and to identify the maximum number of housing units allowed by zoning. For commercial and industrial development, the standard approach is also to disaggregate the land supply by zoning category, identify the number of acres in each, and to use some form of employment-per-acre ratios to determine employment capacity.

Though simple in concept, the standard approach has technical complications. Many of the technical issues concern the precise housing and employment densities that are allowed for each zoning classification. For some residential zoning categories maximum density is quite clear: e.g., R5 allows 5 units per acres. For others (e.g., planned unit developments and mixed use urban centers) maximum housing and employment densities are ambiguous. For industrial and commercial zoning categories, maximum employment densities are usually unspecified and appropriate employment ratios difficult to obtain.[11]

Because development often occurs at densities less than the maximum allowed by zoning, Metro (1997a) incorporated an underbuild factor in its capacity measures. Specifically, Metro assumed that development will take place at only 80 percent of maximum capacity allowed by zoning. The use of such factors may provide a more realistic assessment of future development densities, but it confuses measures of development capacity with elements of a development forecast (Knaap 1998c).

The Demand for Urban Development

The above procedures yield a measure of the net supply of developable, serviced land and the development capacity of such land. But it is impossible to assess the adequacy of development capacity without some assessment of development demand. The demand for urban land is derived primarily from a demand for built space, which is driven fundamentally by changes in the amount, preferences, and resources of businesses and households (i.e., by employment and population growth). Demand for built space and land can be measured in at least two ways. The traditional way is to choose some arbitrary period of time and estimate the accumulated demand for development over that period. The alternative way is to monitor the rate of capacity absorption and to estimate the time at which capacity is fully absorbed. We address the traditional approach below.

Forecasting Population and Employment Growth

The traditional planning process begins with a population and employment forecast. Population forecasts can be made in a variety of ways, including trend extrapolation, ratio-share techniques, statistical association techniques, age-cohort analysis, and others (Kaiser et al 1995). Employment forecasts can similarly made using trend extrapolation, ratio-share analysis, or using economic base, input-output, and econometric models. Population and employment forecasts can also be made simultaneously since, in theory, each depends on the other.

Any attempt to make reasonably accurate and defensible long-run forecasts of employment or population is replete with theoretical and empirical problems well known to planners, demographers, and economists. Any forecast based only on past trends in the dependent variable runs the risk that unspecified but important causal variables will shift in ways that cause the dependent variable to change its trajectory. Any forecast based on a detailed causal model can never be detailed enough, and to a large extent faces similar problems of forecasting (often by assumption) the independent variables. Ultimately, long-run population and employment forecasts are educated simulations of possible futures based on many assumptions.

To this general problems of demand forecasting, we add a couple of relevance to the topic in this paper. In many cases such forecasts lies beyond the capacity of planning staff and are prepared by consultants or state agencies. Using forecasts developed by others, however, can be problematic if the geographic unit for which the forecast is prepared is not coterminous with the geographic unit being planned. In such cases judgment must be exercised in choosing how much of the forecast population and employment growth will occur in the area being planned. Similar problems can arise when the horizon of the forecast does not match the horizon of the plan.

In addition, there is the problem of incorporating the effects of growth management (public policy) on population and employment growth. If growth management is undertaken to alter development trends, then forecasts based on historical trends or data can no longer serve as the basis for the population and employment forecast. Thus, the standard planning approach either cannot serve to alter land market trends, or is based on market trends that are directly contradicted by growth management policies (Knaap 1998a). In other words, the forecasts simulate a possible future that public policy then tries to change.

This paradox has been recognized for many years (Harris 1960) and has stimulated the development of mathematical programs designed to achieve land use goals while minimizing interference in market processes (Hopkins 1974). Such models suggest that it is useful to prepare a land use plan based on a forecast of market trends, to prepare one or more alternative plans that may alter market trends, and to adopt a land use plan that balances the benefits of moving toward the ideal plan against the costs of diverging from the market-based plan. Such a procedure would include standard planning procedure and address explicitly how growth management diverges from market trends, with an accounting of the benefits and costs of such divergence. Forecasts that incorporate such techniques are sometimes called normative forecasts (Isserman 1984).[12]

Forecasting the Demand for Housing and Residential Land

Forecasting the demand for residential land follows directly from the forecast for population. According to Kaiser et al (1995), the process involves four steps:

a. Analyze quantity types, density, cost, condition, and location of existing housing and describe trends relevant to new housing;

b. Estimate the total number of new dwellings required to house the future population of households;

c. Estimate the proportions of the total that will be required for each of several future dwelling types, densities and perhaps tenure or neighborhood types; convert proportions to quantities of dwellings;

d. Convert the quantity of dwellings, by housing type, to acres of land required, by housing types.

Step (a) involves an inventory of the existing housing stock and an assessment of housing trends. Such information is useful for assessing the housing conditions of the existing population, identifying housing in need of repair or redevelopment, and providing a baseline for projecting future housing demand. Land use statutes in Oregon, for example, require explicit justification if future residential densities are planned to be higher than existing densities or the densities of recent developments.

Estimates of the number of required new dwelling units in step (b) derive from estimates of the future number of households which are typically made by subtracting from the total future population the population that will live in group quarters and dividing the remainder by the average household size. The average household size can be determined using historical trends or can be estimated using demographic data and trends. Myers (1987), for example, shows how forecasts of the number of households can be improved by careful estimation of headship rates disaggregated by demographic groups.

Estimates of the proportions of the total households that will be allocated to specific dwelling types, densities, and neighborhoods in step (c) can also be made using historical trends. More specific forecasts can be made using demographic data and trends. ECONorthwest (1999, and also in Lane Council of Governments 1997), for example, shows how demographic data can be used to disaggregate housing forecasts by type and density using crosstabluations by demographic groups. ECONorthwest cautions, however, that such crossstabulations are difficult, approximate, and hard to match to housing types, and that it is difficult to project the housing demand of future households based on the demand of existing households.

Finally, estimates of dwelling units become estimates of land consumption in step (d) by dividing the number of dwelling units in each housing type category by the average density, where density may vary by neighborhood. Such a procedure, like all the procedures described above, largely ignores the role that land and housing prices play in the determination of housing and land consumption. To incorporate the influence of prices and policies, Metro developed a comprehensive Residential Land use Model (RELM) that takes as inputs employment and population data, intraregional travel times, and detailed land use data from an extensive geographic information system (Condor 1998). Using a simultaneous system of equations, the model then provides estimates of housing tenure, housing output, housing prices and rents, land prices, lot sizes, housing type and location for up to 40 residential zones and 45 classes of household size, income and age. The model uses correlations between demographic characteristics and housing types, and forecasts of future demographic characteristics, in its forecast of future housing types. Similar models have been prepared for the Eugene, Oregon, metropolitan area (Waddell 1998). Although models of this type remain beyond the financial and technical capacity of most local governments, they illustrate how trade-offs between urban sprawl and housing consumption decisions can be rigorously examined.

Forecasting the Demand for Commercial, Industrial, and Other Land Uses

Forecasting the demand for commercial and industrial land uses are typically done two different ways. For industrial uses, Kaiser et al (1995) recommend the following steps

a. Determine the number of employees to be accommodated

b. Develop future employment density standards, that is, employees per gross acres;

c. Divide the future number of employees by density standards to estimate the number of acres that will be required;

d. Add a safety factor.

The number of employees to be accommodated in step (a) follows directly from the employment forecast, though employment growth is often treated as an objective as well as a variable in land use plans. Thus, employment growth may be influenced by the development plan and employment forecasts may be in part driven by forecasts and part by policy (Knaap 1998b). Similarly, employment density standards, developed in step (b) must be partly estimated and partly chosen. Employment density data are available from a variety of sources including, perhaps, historical records. But employment density patterns vary widely even within standard industrial classifications and are unlikely to remain constant over time (Waddell, Moore and Edwards, 1998). Thus considerable judgment must be exercised when using such standards to determine the number of required acres in step (c). As a result, and in part because the cost of an underestimate is generally viewed as greater than the cost of an overestimate, generous safety factors are often added in step (d).

To estimate the demand for office and commercial land uses, Kaiser et al (1995) recommend the following steps:

a. Estimate total retail and office floor area requirements based existing floor areas and expected rate of growth;

b. Allocate total retail and office floor areas to commercial and employment centers;

c. Identify retail and office ground floor area requirements;

d. Identify area needed for parking, loading, waste and landscaping, and contingency;

e. Identify total areas by summing all the elements of c. and d. above.

According to Kaiser et al, the growth factor in step a. can be found by assuming that retail floor and office space is proportionate to population and thus by using a population growth factor. Alternatively, they suggest, the growth factor can be found using specific office employment forecasts, for office space, or expenditure forecasts for retail space. The distribution of space to centers, in step b. can be based on the existing distribution, land use goals and policies, trends in shopping behavior and merchandising practices, and the transportation plan. Total ground floor area requirements in step c. can be found by dividing total floor space by the average number floors in office and retail use. The additional area needed for parking, loading, and other uses, calculated in step d., is likely to vary from center to center. Retail and office spaces in downtown areas, for example, may require less space than areas located near interstate freeways. The additional land allocated for these uses will reflect existing trends and local standards.

To estimate the demand for land for all types of employment, Metro (1999a) developed an integrated Zonal Employment Land Demand Analysis model (ZELDA). This model is used to generate estimates of employer demand for land in specific zones of the metropolitan area disaggregated by standard industrial classification. The process begins with a forecast of economic growth for the entire metropolitan area which is then allocated into subareas using RELM, stochastic sub-area regression models, and Delphi techniques. Then, based on extensive analyses of employment densities, building densities, and floor-area ratios, estimates of land demand are made for industrial, retail, office and other commercial uses for each sub-area.

Monitoring Urban Land Markets

As described above the traditional approach to land supply management has been to conduct periodic inventories of developable land, forecast the demand for urban land development, and allocate and adjust the supply accordingly. The potential of continuous land supply monitoring offers the possibility of an entirely different approach—one in which the absorption of land is monitored continuously and supply and allocation decisions are made as needed. The dates at which such adjustments become necessary are based on information regarding the absorption rate of land and infrastructure capacity, land and housing prices, and housing affordability. We address the elements of such an approach below.

The term land monitoring system began to be used in the 1980s to describe database systems that include both periodic land use inventories and records of land development events. According to Godschalk et al (1986) such Automated Land Supply Information Systems contain two types of files: (1) a parcel file derived from assessors' records, and containing ownership, values, and use for each parcel in the jurisdiction, and (2) project files, derived from applications for subdivision plans, planned unit development and site plan approval, and containing dates of development milestones and its stage in the process of development review. Separate files may be kept for other purposes, such as tracking building permits, sewer permits, and environmental conditions.

Systems of this type incorporate information on both the supply of developable land and on development events, though the two are not integrated in any systematic way, and thus are of limited use for urban planning or management. In a recent analysis of land supply monitoring by local governments, for example, Moudon and Hubner (1999, p.25) state: "Few, if any, jurisdictions have managed to establish monitoring systems as an on-going inventory of the entire land supply. Neither have they used it as a tool to measure on a regular basis the effectiveness of policies and regulations and the possible impacts of new regulations, policies, or land development practices."

Monitoring Land and Housing Market Activity

The practice of monitoring land and housing market activity is not new. Data on housing starts and building permits have been recorded by the Bureau of the Census for many years. And for some time, local governments have maintained information on rezonings, subdivisions and special permits, increasingly in an electronic format. A number of "permit tracking" and other administrative database systems are now commercially available. What is new, however, is the use of monitoring as a means of updating measures of development capacity and the use of capacity adjustment rates as the basis for growth management decision making.

Conceptually, the task of monitoring land market activity is simple. In practice, it is difficult. Hopkins and Knaap (1998) suggest that land market activity can be monitored using the perpetual inventory method, which "involves a continuous accounting of incoming materials, outgoing materials, and the balance of materials on hand." The basic concept of a perpetual inventory is presented in Figure 4, which shows transaction records for two inventories: (1) residentially zoned land within the Urban Growth Boundary that is not subdivided, and (2) subdivided residential land. Land is added to the first inventory when area is added to the UGB and is subtracted when land is subdivided. Land is added to the second inventory when it is subdivided and subtracted when building permits are approved. Critical to the effective use of the perpetual inventory method is clear and logical specification of the inventory organization, including a carefully defined classification system, unique parcel numbers, and verification processes.

Figure 4a: Inventory Record for Residential Land within Urban Growth Boundary

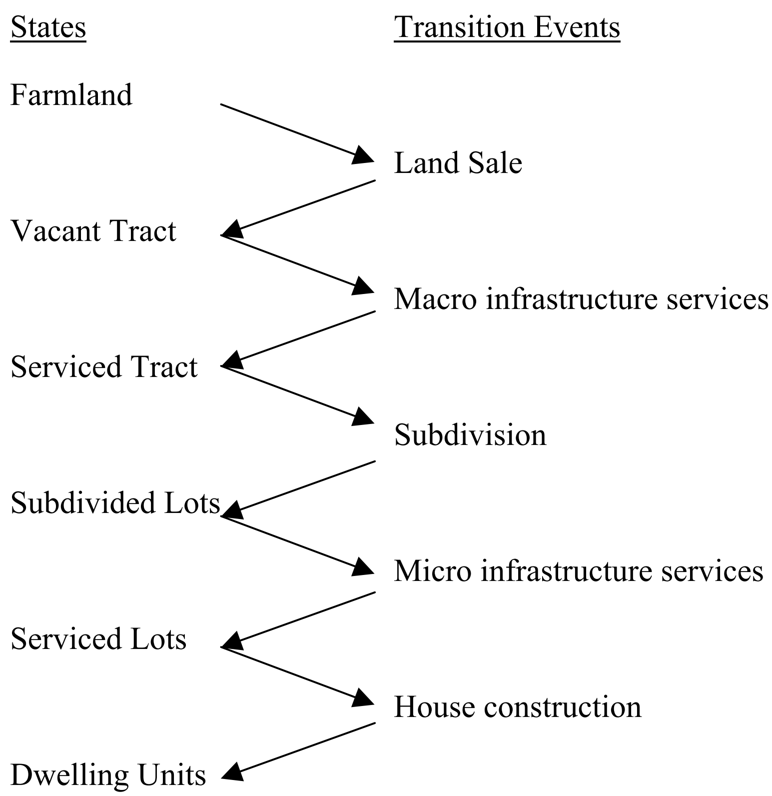
Date	Event	Received	Shipped	Balance
	Initial balance			1,000 acres
10/2/98	Add residential to UGB	100 acres		1,100 acres
12/10/98	Subdivision approval		60 acres	1,040 acres

Figure 4b: Inventory Record of Subdivided Residential Land

Date	Event	Received	Shipped	Balance
	Initial Balance			200 acres
12/10/98	Subdivision approval	60 acres		260 acres
1/25/99	Building permits		15 acres	245 acres

A significant advantage of the perpetual inventory method is continual verification. In practice, inventory records are most suspect immediately after the initial physical inventory of stock is taken. As Figures 4 and 5 show, land moves through a sequence of inventories as a sequence of events changes land from one state to another. Each of these inventories may be described by multiple attributes. For example, the land at one stage may be zoned for residential use, vacant, subdivided into lots, and serviced. The stock of such land would be changed by any event that changed any one of these attributes.

Figure 5: The Land Development Process



Land and housing activity is tracked for supply monitoring purposes, at least in part, by Metro. Metro obtains building permits from local jurisdictions and geocodes them to specific coordinates in its Regional Land Information System (RLIS), Metro's comprehensive GIS. Once geocoded, Metro uses the permit data to analyze the density and rate of housing development by various geographies. Though various quality control measures are taken, the geocoding process remains imperfect. Not all building permits, for example, are issued to specific tax lots. Further, building permit records are often duplicative and incomplete. According to Metro (1997c), however, most building permits eventually geocode to tax lots after updated assessor information is received.

Metro also uses permit data to monitor the rate of vacant land absorption. Vacant land absorption is measured by overlaying annual aerial photographs over plots of building permit data. Similar procedures are used to identify additions to vacant land through demolitions. Vacant land absorption is monitored to provide an early warning if the 20-year growth capacity is critically short (Metro, 1997c). Metro also maintains data on annexations, subdivisions, zoning, plan designations, and other development events, but does not use them for continuous land supply monitoring.

Monitoring Retail, Office, and Industrial Land Markets

Like the practice of monitoring residential land and housing markets, the practice of monitoring retail, office, and industrial land markets is not new. What is new is the potential to monitor activity in a nearly continuous fashion and to use the information for land and infrastructure supply decisionmaking. Monitoring can begin with systematic monitoring of building permits and the land development process. Thus, the conceptual framework for monitoring retail, office, and industrial activity can begin with the framework outlined residential land by Hopkins and Knaap (1998). Retail, office, and industrial land markets differ from residential land markets in significant respects, however, that warrant differences in monitoring systems.

One gets to estimates of residential land consumption through dwelling units and lot sizes (or density). But retail, office, and industrial developments are not counted as units; they are typically measured in square feet of building space, which converts to land consumption through a different measure of density: the floor-area ratio (building space divided by land area). Floor-area ratio is thus an important variable to monitor in all three of these types of land markets.

Employment is also an important variable in each of these markets, since employment is the key driver in retail, office, and industrial market forecasting. Small changes in the ratio of employment to floor area, or in the ratio of building space to land area, can cause significant changes in forecasted needs for retail, office, and industrial lands (Metro 1999a).

For retail markets, sales is also a key variable. Unlike office and industrial land markets, the demand for retail space is generally governed by local expenditures. For this reason, McClure (1998) shows how cycles in retail markets can be mitigated by monitoring population, sales, and square feet of retail space and using such information to regulate the flow of retail spaces.

For all three types of land markets, information should be disaggregated by type and location. For example, office space would be disaggregated by class of office space (e.g., class A, B, C) and by downtown and suburban locations. For industrial space, information should be disaggregated by intensity of use (e.g., heavy industrial, light industrial, and industrial parks) and by access to different types of transportation facilities (Puget Sound Council and the University of Washington Center for Community Development and Real Estate 1998). For retail space information should be disaggregated by types of retail activity (e.g., grocery, department, or discount stores) and by neighborhood, regional, or metropolitan orientation.

Monitoring Infrastructure Capacity

In many respects, monitoring infrastructure capacity is easier than monitoring urban land markets. With the exception of combined sewers and multimodal road systems, the use of infrastructure is uni-dimentional. Wastewater plants treat wastewater; landfills hold solid waste, potable water systems deliver water, and parks provide recreation and open space. Further, capacity for most forms of infrastructure can be clearly defined in terms of vehicles, gallons, cubic yards, or persons in total or per unit time. Network problems can be handled through disaggregation by network link (e.g., road segment or sewer pipe).

Infrastructure capacity is treated by land use planners as part of the capital improvement process which, according to planning literature, should be addressed in a capital improvement plan—"a multi-year schedule of public physical improvements" (Bowyer, 1993, p. 1). Such plans, however, are usually more closely tied to the budget process than to the comprehensive plan; as such they serve more to allocate municipal expenditures than to allocate service capacity. Capital improvement plans do not, therefore, provide an institutional framework for infrastructure capacity monitoring.

Concurrency regulations, however, provide a framework and incentive for infrastructure capacity monitoring. Since concurrency regulations prohibit urban development without adequate infrastructure in place, local governments have a need for timely information on infrastructure capacity levels. According to a 1991 survey of local governments in Florida (Audirac et al 1992), 47 percent of respondents indicated that they monitor service capacity. Some of these monitor capacity annually, but most monitor on a project-by-project basis, and did so for transportation, potable water, sanitary sewer, drainage, solid waste and mass transit. Details on how capacity is monitored and how such monitoring affects development and capital improvement programming is not provided.

Monitoring Land and Housing Prices

Monitoring land and housing prices is not a traditional activity of local governments, although local governments have prepared comprehensive housing assessments for many years. Interest by local governments in land and housing prices has largely developed out of pressure from the development community, which has argued that growth management has led to artificial price inflation. Considerable evidence supporting this claim has been provided by academic economists (Fischel 1991).

Approaches to land and housing price monitoring take three general forms: unadjusted reports of sales data, repeat sales analysis, and hedonic price estimation. Unadjusted reports of sales prices are most common. Such reports include, for example, the average or median sales price of housing or finished lots. Data on the former are often available from local home builder or real estate associations at the metropolitan level, but data on housing prices at the jurisdiction level and data on land prices remain surprisingly rare. Unadjusted medians and means, moreover, do not control for potential changes in the characteristics of the sample. The median price of housing in a jurisdiction may increase over time, for example, if the size of the average house sold has increased over time.

Price indices that use repeat sales and hedonic prices do control for potential changes in the sample over time. Repeat sales indices control for potential changes in the sample by holding the sample constant over time. That is, repeat sales indices are based on at least two sales observations of the same house; therefore, by assuming the size or other qualities of the house have not changed over time, the change in the price of the house provides one observation of general changes in the price of housing in the community.

Repeat sales indices, however, have two major limitations. First, there is generally no way to know whether significant changes in a house have been made between first and subsequent sales observations without field work. Second, the number of repeat sales in any given jurisdiction is likely to be small and not representative of the overall housing stock. Houses that sell often may, for example, be houses with flaws that are difficult for home buyers to observe until they own the house. They may also be small starter homes whose prices tend to fluctuate over the business cycle more than the average home. In these cases, indexes based on repeat sales will provide a biased measure of overall changes in housing prices (Englund et al 1998).

Hedonic price indices control for potential changes in sample by including information on sample characteristics. In brief, hedonic price indices use regression analysis in which the price of housing is regressed on measures of housing characteristics, including the date the house is sold. The coefficients on the housing characteristics provide implicit prices of these characteristics and the coefficient on the date sold provides a measure of the extent to which a constant-quality house has increased over time. If a large number of observations are available with information on the many characteristics that influence land and housing prices, and if the regression analysis is carefully performed, then hedonic price estimation provides the best measure of land and housing price change.

Local government rarely, however, have the data or the econometric expertise to monitor land and housing prices using repeat sales or hedonic price estimation. To monitor housing prices, for example, Metro obtains housing sales observations from the county assessors offices, geocodes their location, and reports median sales prices in the various jurisdictions. To monitor rents, Metro uses a rental rate survey conducted by a private consultant and calculates median rents from county assessors data. (Metro 1997c). To monitor land prices, Metro obtains the assessed land values of parcels whose centroids lie in the vacant land coverage. Metro reports average vacant land values by county and by land use type. Tax exempt properties are excluded from the analysis.

Monitoring Housing Affordability

Although land supply monitoring systems must be designed to serve many objectives, assuring that housing remains affordable ranks high among local government objectives.[13] Affordability is, of course, a relative concept. What is affordable to one household maybe prohibitively expensive to another. Nearly all measures of affordability, therefore, involve measures of income and measures of housing expenditures. None is perfect.

Bogdon and Can (1997) discuss three types of affordability measures: those that address housing demand, those that address housing supply, and those that combine elements of both supply and demand. Demand-side measures of affordability generally involve the percent of income spent on housing. Some of these include adjustments for housing quality and some include adjustments for very low income households (Bogdon and Can 1997). None of these, of course, can fully distinguish between low levels of housing affordability and high levels of housing preference. Supply-side measures typically address the number and vacancy rate of units at different levels of price or rent. Depending on data availability, these can be adjusted for housing quality. Combined supply- and demand-side measures compare the distribution of housing prices with the distribution of household incomes. A simple such measure, for example, compares for several income categories, the number of units available priced at 30 percent of household income and the number of households in that income bracket. This measure provides a rough estimate of the match between supply and demand at various levels of housing quality.

With the availability of GIS technology and block group census data, many of these affordability measures can be computed for sub-metropolitan areas. Such information permits spatial targeting of affordable housing policies. Perhaps more important, however, is comparison across metropolitan areas. The National Association of Homebuilders, for example, publishes its "housing opportunities" index for every major metropolitan area. This index measures the proportion of homes sold in a market that could be purchased by the household with the median income in that market (National Association of Homebuilders 1996). Like others, this index has strengths and weakness, but its regular computation for many metropolitan areas represents a distinct advantage.

Although Metro addresses housing prices and rents in its Baseline Urban Growth Data report (Metro 1997c), it addresses affordability most directly in its Housing Needs Analysis (Metro 1997d), which according to Metro Code, is used to evaluate the Metro Housing Goals and Objectives every four years. In this report, Metro presents the number of households that do not live in affordable housing according to the U.S. Department of Housing and Urban Development (i.e., household expenditures exceed 30 percent of household income). Following a discussion on affordable housing needs, tools, and strategies, the report also presents a forecast of the need for affordable housing based on the expected income level of the future population and the expected cost of housing.

The Potential of Monitoring for Smart Urban Growth

Smart growth means different things to different people. Our focus has been on the match between the demand for and the supply of developable land and infrastructure capacity. To us, therefore, it is smart to keep demand and supply in reasonable balance. Though we have avoided the debate on what constitutes a reasonable balance, we have argued that better balancing is possible with better information on both the demand and supply sides of the issue.

It does not necessarily follow, however, that land supply and infrastructure capacity monitoring will lead to better planning and management of urban growth. For years, plans have been developed and growth has been managed with only sporadic attempts to measure the supply and demand for urban development. This may reflect previous technical difficulties and prohibitive costs of establishing continuous monitoring systems, but it also may reflect the lack of a conceptual basis for using continuous information as the basis for urban growth planning and management.

Enduring Issues of Measurement

Although significant advances have been made recently in almost all of the techniques needed to measure the supply of developable land, especially since the development of GIS, a number of thorny issues remain. Many of these have less to do with information about land than in the determination of what land is developable. The resolution of aerial photography has risen to the level where it is possible to determine great detail about what lies on the ground. Further, the frequency of measuring change is limited only by cost and weather. The remaining difficulties largely reflect policy decisions about what constitutes vacant land and to what extent environmental concerns should preclude land development. Similar issues remain for infill and redevelopment potential.

For infrastructure capacity the issues are more complex. Capacity depends on level of service standards, which are as much a matter of policy as of engineering. Further, capacity absorption depends on the location, density, and character of development. Thus, identifying land with adequate infrastructure capacity will always be a contingent exercise, where the contingencies are often too difficult and numerous to articulate. For identifying land with adequate infrastructure capacity, therefore, both significant technical and policy issues remain.

Despite decades of methodological development, forecasting population and employment growth, housing demand, and land consumption remains more art than science, especially at smaller scales and for long periods of time. Population and employment growth remains subject to the swings of business cycles, particularly at the local level, and housing demand varies by business cycles and tastes. Only the demand for land seems insatiable and near-certain to rise regardless of location. A compelling argument can be made, however, that the lack of ability to forecast urban growth with a reasonable degree of accuracy is a primary motivation behind the growing interest in land supply and infrastructure capacity monitoring.

Unexplored Issues in Monitoring

Despite remaining difficulties in measurement, significant progress has been made toward monitoring activity in urban land markets. Much information about housing production is now available with considerable temporal regularity and a high degree of spatial resolution. Considerable information is also now becoming available for some urban areas about land absorption, urban infill and redevelopment, land and housing prices, and commercial and industrial land markets. What to do with all this information, however, remains unexplored.

Lagging distinctly behind the development of land monitoring systems is the development of conceptual models of how the information provided by such systems should be used. At present, many planning procedures and land use decisions still follow rules of thumb adopted 50 years ago—some of which have been codified into law. Meanwhile revolutionary techniques of inventory control remain ignored by land use planners and policy makers. Perhaps there are good reasons why urban growth boundaries should contain 20 years of developable land and reexamined every five years. Perhaps infrastructure capacity should be assessed only when a proposed development meets a concurrency requirement. But perhaps not. Instead, perhaps planners and policy makers should adjust UGBs based on signals provided though land supply monitoring and base the size of UGB expansions on the relative costs of expanding and holding inventory. Perhaps also planners and policy makers should accommodate urban growth in accordance with infrastructure capacity absorption and infrastructure investment cycles. Perhaps, therefore, now is a smart time to explore the technical and conceptual foundations for doing so.

Endnotes

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[1] There has been substantial recent writing in the professional literature of land planning and land economics on how to define urban sprawl, and whether, once defined, it is desirable or undesirable. We will not enjoin that debate in this paper. We limit ourselves to the conclusion that, independent of whether some amount of a development pattern called "urban sprawl" is on net beneficial or not, a lot of growth management policies aim at changing that pattern.

[2] These include Oregon, Washington, Maryland, Minnesota, Tennessee, and Maine

[3] This is not the exact language.

[4] The optimal minimum stock is the lower end of the range of stock that balances the excess supply in the early period of the fixed interval with the excess demand in the later period. See Ding, Knaap, and Hopkins (forthcoming)

[5] In a fixed-interval system, the order size and minimum inventory are determined by the length of the interval between orders and the planning horizon at the time of the order.

[6] One such hybrid is called the (s, S) system where the inventory is measured at fixed intervals but replenished to level S only if the level of inventory has fallen below level s. See Sipper and Bulfin (1997) for more on this and other inventory systems.

[7] The recent listing of Salmon on the endangered species list has added additional complications to this issue in the pacific northwest (Metro 1999).

[8] Redevelopment usually yields a net increase in developed space (housing units, commercial or industrial square-footage) to accommodate growth, but it need not.

[9] Put another way, Metro's approach uses the rate of refill capacity absorption to estimate refill capacity (Knaap 1999).

[10] See also Budd (1992).

[11] Recent work by ECONorthwest attempting to relate employment by address by four-digit SIC code (through ES202 tapes) to built space and land area (through local assessment and land use data) through GIS matching show that even at the four-digit level the variability in land consumption per employee (employment density) is very large.

[12] Examples of plans that reflect such an approach, at least in part, include Seattle 2020, Metro 2040, and Envision Utah.

[13] Broader than the concept of "affordability" is the one of "need." It is unlikely that housing markets in any metropolitan area in the US provide housing to meet the needs of every household. Even many upper-income households probably believe they "need" more housing than their wealth and income allows them to afford. More important, however, are more basic housing needs. At the extreme there is homelessness: some people do not have any shelter at all. Close behind follows substandard housing (with health and safety problems), space problems (the structure is adequate but overcrowded), and

economic and social problems (the structure is adequate in quality and size, but a household has to devote so much of its income to housing payments that other aspects of its quality of life suffer). Moreover, while some new housing is government assisted housing, public agencies do not have the financial resources to meet but a small fraction of that need. New housing does not, and is not likely to fully address all these needs. In this section, however, we limit our discussion of need to issues of affordability.

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