Chapter 3: A Study of Regional Growth Planning: the MassGIS CPI buildout analysis

Using empirical evidence is always helpful in elucidating a theory. In this case, we are interested in looking at a common class of planning analysis that is undertaken by practitioners (as opposed to academics), is widely used, and is relatively modern. The analysis presented here was chosen for the following reasons:

1. It addresses growth management, one of the most pervasive concerns of urban planning.
2. It covers many different types of places, being intended for use by all 351 cities and towns in Massachusetts.
3. The range of jurisdictions involved is diverse, including state agencies, local planners, zoning boards, elected officials, and private sector consultants.
4. Growth planning has intrinsic spatial qualities, ensuring that work on this problem will take into account the special concerns of spatial information.

This chapter begins with an overview of Massachusetts' Buildout analysis, a planning support system that calculates maximum residential and commercial land use based on a town's current zoning. As this is not a formal case study, many details are left out, such as its evolution, its role in the state's larger growth management efforts, and even its successes and failures. Instead, we infer its importance by the fact that it was enacted and funded, and all 351 municipalities have been analyzed. After a brief introduction to the enabling legislation that funded it, a detailed description of the analysis is presented, focusing on data requirements and analytic methodology. Finally we abstract out the major themes of the analysis, the types of organizations involved and the level of coordination required of them, and the sustainability of the work, or its ability to be repeated as its assumptions change. The intent of this chapter is to take a concrete, practical analysis and use its strengths and weaknesses to highlight the issues that must be addressed by any framework for urban information management, and ultimately to drive the design of new software.

Policy Background

Where do you want to be at buildout?[1] That is the fundamental question posed by Massachusetts' Community Preservation Act (CPA). Initiated by the Executive Office of Environmental Affairs (EOEA) and enacted in December 2000, this effort seeks to, "promote smarter land use to preserve and enhance the quality of life in communities across the Commonwealth." (*Buildout Book*, 2001). Put in a broader context, this is a statewide planning initiative geared towards curtailing unchecked land development falling squarely in the policy arena of "smart growth." The Act contains a number of policy instruments designed to help municipalities make their own, better informed planning decisions. Small grants are given to develop Community Development Plans, and "Fiscal Impact" and "Alternative Futures" tools have been built and are available for local use. The focus here is on a tool developed by MassGIS and regional planning

[1] Buildout is defined as the maximum development allowed by right according to a municipality's regulations—most notably zoning, but also including environmental protection, site suitability, etc.

agencies, the Buildout analysis, which maps out the consequences of full development under current zoning regulations.

The general objective of the buildout analysis is to predict the maximum number of new homes, residents and businesses allowable under current zoning regulations. The hope is that having this information will encourage towns to revise their zoning to better reflect the amount and type of development they desire. The analysis begins by excluding protected open space and other lands having permanent development restrictions from development. All previously built up residential, commercial and industrial areas are also excluded at this point (a side effect is that this model does not allow for redevelopment). The remaining land is then assigned values for new homes and businesses based on the lands' zoning classification. In cases where there is likely to be some limitation to development, as in wetlands and on steep slopes or poor soils, a heuristic is applied to reduce the development potential of the area by some amount.

The intent was not to build an operational model that would help towns develop better growth policies, but to simply spur communities to become concerned about the issue. No one really believes that full buildout will occur throughout the Commonwealth or even throughout a community. But it is well within the realm of possibility that full buildout could occur in a block or neighborhood, and this can have a devastating impact on the character of a community.

Buildout is not a particularly exciting analysis from a modeling standpoint. There are only two time periods available for examination—the current state of the town, and its state at full development. Also, the development rules are very simple. In this model, development is mainly limited by environmental factors. If the land's building capacity is not constrained by steep slopes, bad soils, wetlands or floodplains, it gets developed to the highest density allowed by zoning. There is no accounting for economics or transportation constraints, for example. In addition, since time is not a part of the model, buildout could occur in ten years or ten thousand. However, these factors that make the model less realistic from a growth planning point of view are there for a reason. Each one of the 351 cities and towns in the Commonwealth has been run through the analysis. The data requirements and analytic methodology were designed to be within the abilities and budgets of even the smallest towns, so that the effects of development could be seen not only for every town, but also regionally across jurisdictions. This comprehensiveness makes the buildout analysis extremely interesting from the point of view of one interested in examining information-dependent analysis systems that have wide application.

Process

The buildout model has the following general structure:

1. Identify zoning districts that permit development.
2. Remove areas that are already developed (even if they might be under-developed).
3. Remove areas that are absolutely unsuitable for development (due primarily to environmental constraints).
4. Identify areas that may only support partial development due to environmental constraints such as the presence of wetlands or floodplains. Compute a statistic for these areas that indicates how much “less” developable these lands are than those with no constraints.

5. Compute the number of new residences and businesses that can be developed based on zoning attributes such as floor-area ration (FAR) and lot setbacks.

The maximum buildout envelope—Zoning (step 1)

The buildout analysis uses a town's zoning laws to determine maximum development. This may seem logical, but it is actually quite different from the approach taken in common growth models such as CUF or UrbanSim, who base their development estimates on more realistic assumptions than *full* zoning buildout. The point being made in Massachusetts, however, is why have a zoning plan that you have no desire to see realized? The intention being to have communities thoughtfully revisit their land use regulations from the standpoint of what do they desire twenty years from today. This is MassGIS' guidance on how to integrate zoning data:

The contractor will develop or update zoning (ZONE) and zoning overlays (OVER) from the most current town zoning map or maps, digitized with reference to the most current town zoning by-law and registered to the town boundary layer from MassGIS. The polygon attribute table of these GIS layers must conform to the MassGIS/RPA standard for attributes as implemented in the MassGIS library which is attached to this contract. Zoning overlays should be digitized only if they will have a real impact on development – in many cases they impose minor restrictions which won't affect the basic buildout analysis.†

The incorporation of zoning data into the model would seem straightforward, but this is complicated by the need to unify all the towns' zoning classifications and definitions to a single standard. Otherwise there would have to be a (slightly) different model for every different zoning manual.

Current buildout—Land use and Subdivisions (step 2)

The MacConnell land use will be part of the analysis and needs to be reclassified to show residential, commercial/industrial and undeveloped land.†

Establishing baseline development involves three data inputs. MassGIS starts with a statewide land use coverage to identify areas already developed as residential or industrial/commercial. This data set was developed from aerial photography interpretation. Since these photographs were taken throughout the 1980s and 1990s, they are a bit out of date, and they are not very precise, so small, isolated land uses are missed due to their 1:25,000 (1 inch equals about 0.4 miles) scale value where the minimum mapping unit was one acre.

In order to map subdivisions and/or to update the land use mapping, which will be critical inputs to the process, the contractor should look at the history of subdivision filings since the date of MacConnell land use mapping. If there are a sufficient number of non-ANR subdivisions to warrant, a separate subdivision layer should be created. Essential attribute information to be collected and assigned to the subdivision polygons includes subdivision-id, name, date, number of lots, number of houses built to date and total acreage. Ideally this information would come in soft-copy form and could be linked to the subdivision mapping. Additionally the contractor should obtain any available map showing the new subdivisions at a scale suitable for transfer to a town-wide map.†

Augmenting this statewide land use coverage with local knowledge can solve both the precision and currency issues. For this reason MassGIS requires towns to update land use using a higher resolution aerial photography set flown in 2001. All towns, however, will not have ready access to someone skilled in the art of aerial photography interpretation, so all that can be asked of the town is that they identify residential and commercial/industrial uses, whereas the official statewide land use data set classifies land use into 21 to 33 types, depending on who did the interpretation and when it was done.

2001 is still a bit old for some towns, even in one of the slower growing regions of the country. The final input to current development is a residential subdivision data set that the town may optionally provide. This can only be created in a cost-effective manner if developers have submitted electronic plans and the local government uses them.

Just like zoning, land use data must be provided to the model in a generic data schema, so towns must follow MassGIS' guidance on land use updates and subdivision data development.

Absolute constraints to development (step 3)

Some lands are considered not developable in this model. In addition to those already built up areas described above, there are a number of land use types that are excluded from development by either environmental or legal constraints. In this model, this refers mainly to permanently protected open space and farmland. This type of property is defined as "land which is held in fee ownership by a government agency or a private non-profit organization for the purpose of conservation or water supply protection or which has deeded restrictions on development" (MassGIS). MassGIS already is the official maintainer of a statewide data set cataloging open space in a high degree of detail, so the acquisition and use of this data is trivial.

Partial constraints to development (step 4)

The buildout analysis has a concept of “partially developable” lands. These include wetlands, steep slopes and flood plains. These types of land are considered un-developable in most models, and this model is no different in that it does not allow structures to be built in these areas, this model is more realistic if a portion of these areas are projected to be part of a built-up lot, because they could fall into that lot’s setback or open space allocation.

The actual amount of development permitted in these areas is based upon a combination of site-specific factors, including the size of the zoning district, the size of the partially developable area in relation to the district, and the type of development allowed in the district. For this reason, these factors are computed on a case-by-case basis in a spreadsheet.

Finally, after analysis of the town zoning by-law and the other source documents collected above, the contractor will determine if any other legal, physical or environmental factors will so significantly influence or constrain future development in the town that no reasonable buildout analysis can be done without considering them.

Finally, MassGIS allows each town to have a “wildcard” layer. This allows towns to use their own judgment to exclude from development anything that the generic analysis overlooked. This is a very interesting feature of the methodology, as it seems to contradict the basic principles of doing a standardized analysis. But in order to have truly committed participation in the system, this is a useful way to make sure every town's unique needs are addressed.

Buildout computation (step 5)

Three types of summary table may be produced from the polygon attribute table for potentially developable land from step 7. One table gives, for each zoning district classification, the total area within the town for each combination of constraints present within that zoning district. Thus, if floodplains are mapped as a partial constraint, the town might have 2000 hectares of R1 district without any constraint, and an additional 100 hectares of land in the R1 district that are in the 100 year floodplain. This table can be the basis of the analysis of a generalized analysis that provides a rough estimate of buildout potential. If all constraints are treated as absolute constraints, then there is simply one record for each zoning category giving the total potentially developable area within that district.

Optionally, a second, more detailed analysis will require summarizing by individual zoning polygon – this would be appropriate where the distribution of partial constraints is very irregular and certain polygons end up with little or no allowable building because of an atypical concentration of constraints. In this case, the zoning polygon –id should be referenced to a map with those –ids printed for the individual zoning polygons. Finally, if parcel mapping is available, the analysis can be done to summarize for each parcel (or each parcel above a certain minimum) the characteristics of that parcel.†

The buildout is ultimately a computation of the number of new residences and offices that may be developed. The analysis just described, which was mainly spatial in nature, provides a list of zoning districts and the proportion that may be developed. In the case of areas with no constraints, this proportion is 100%. In areas with partial constraints, the number is less, and where the constraints are absolute, the number is zero. At this point, it is a matter of simple mathematics to compute the number of structures that can be developed based on the zoning code's attributes, such as minimum lot size, setback requirements, road frontage, etc. This step is also performed in a spreadsheet environment.

The results

The results of a buildout analysis are a series of maps and statistics describing maximum buildout potential in the municipality. The series of maps have already been presented here, and they serve the same purpose as they do here, which is to graphically illustrate the analytic process. The statistics are the buildout computation described in step 5. It is worth reiterating that the intended result is not to tweak this model so that the maximum buildout based on zoning regulations matches the town's development objectives. EOEA simply hoped to catalyze local interest in urban growth policy. This is no different, however, than the goal of most planning efforts—even those based heavily on expert analysis.

Figure 3-1: Absolute Constraints for Sutton, MA Buildout

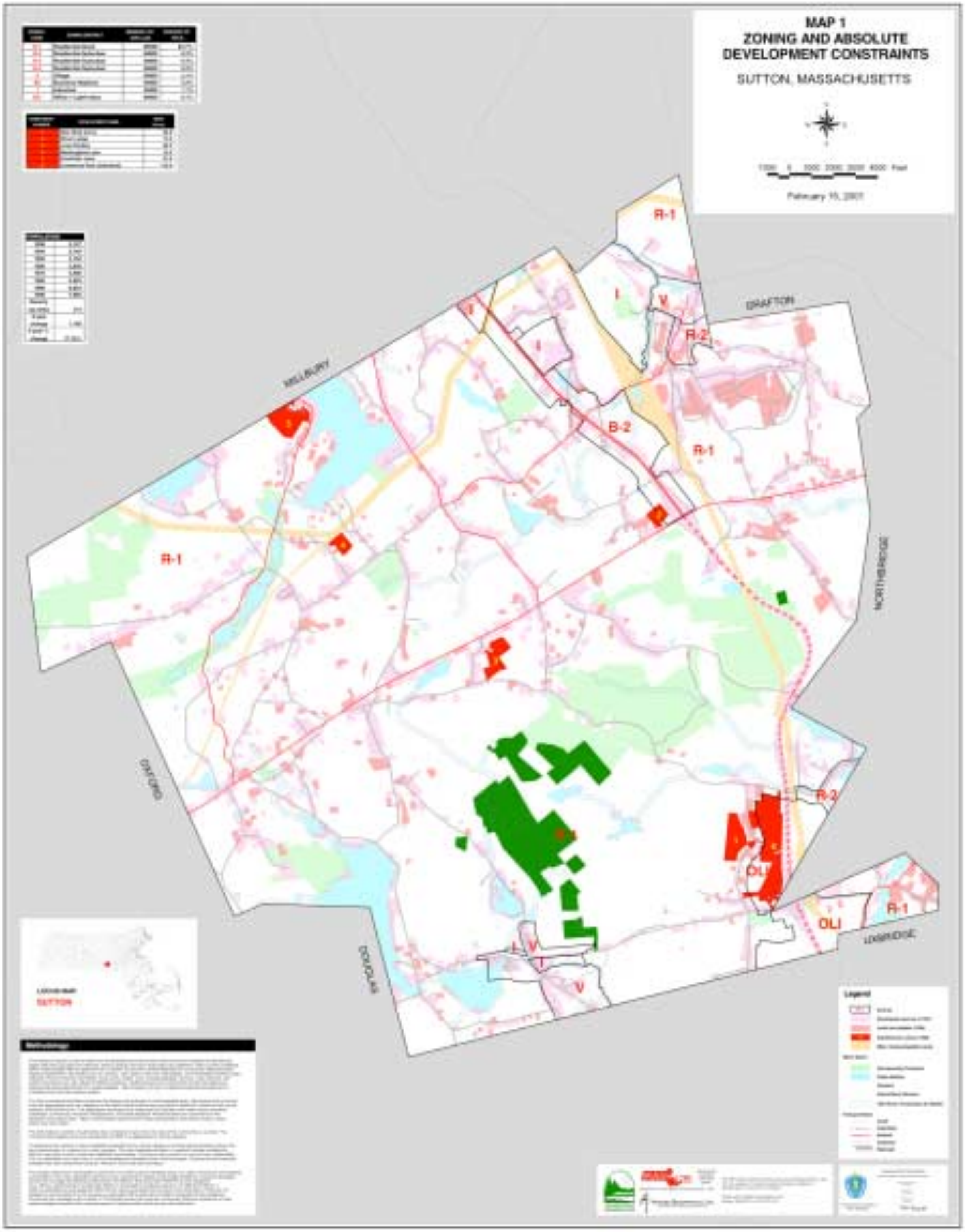


Figure 3-2: Developable Lands and Partial Constraints for Sutton, MA Buildout

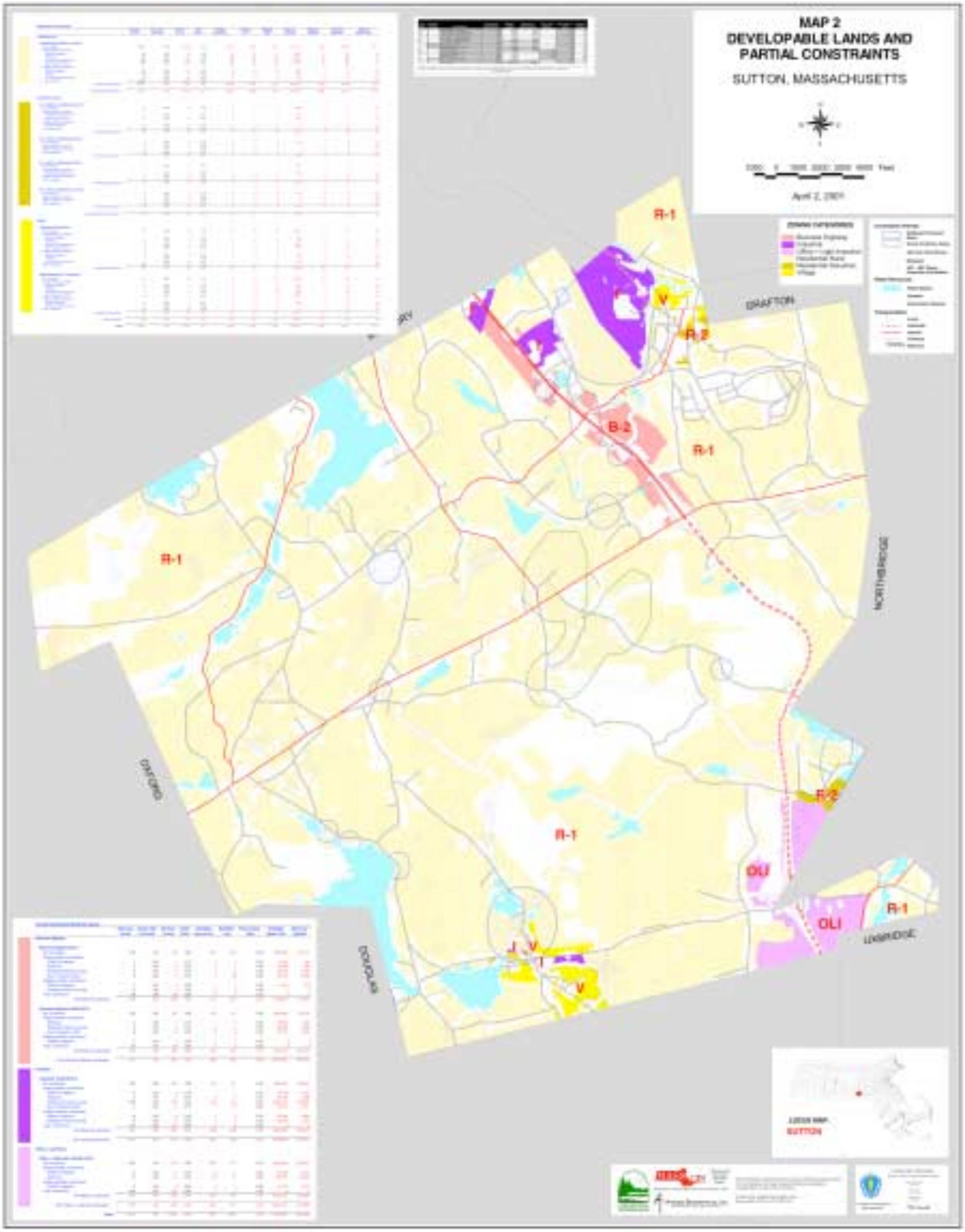


Figure 3-3: Composite Development for Sutton, MA Buildout

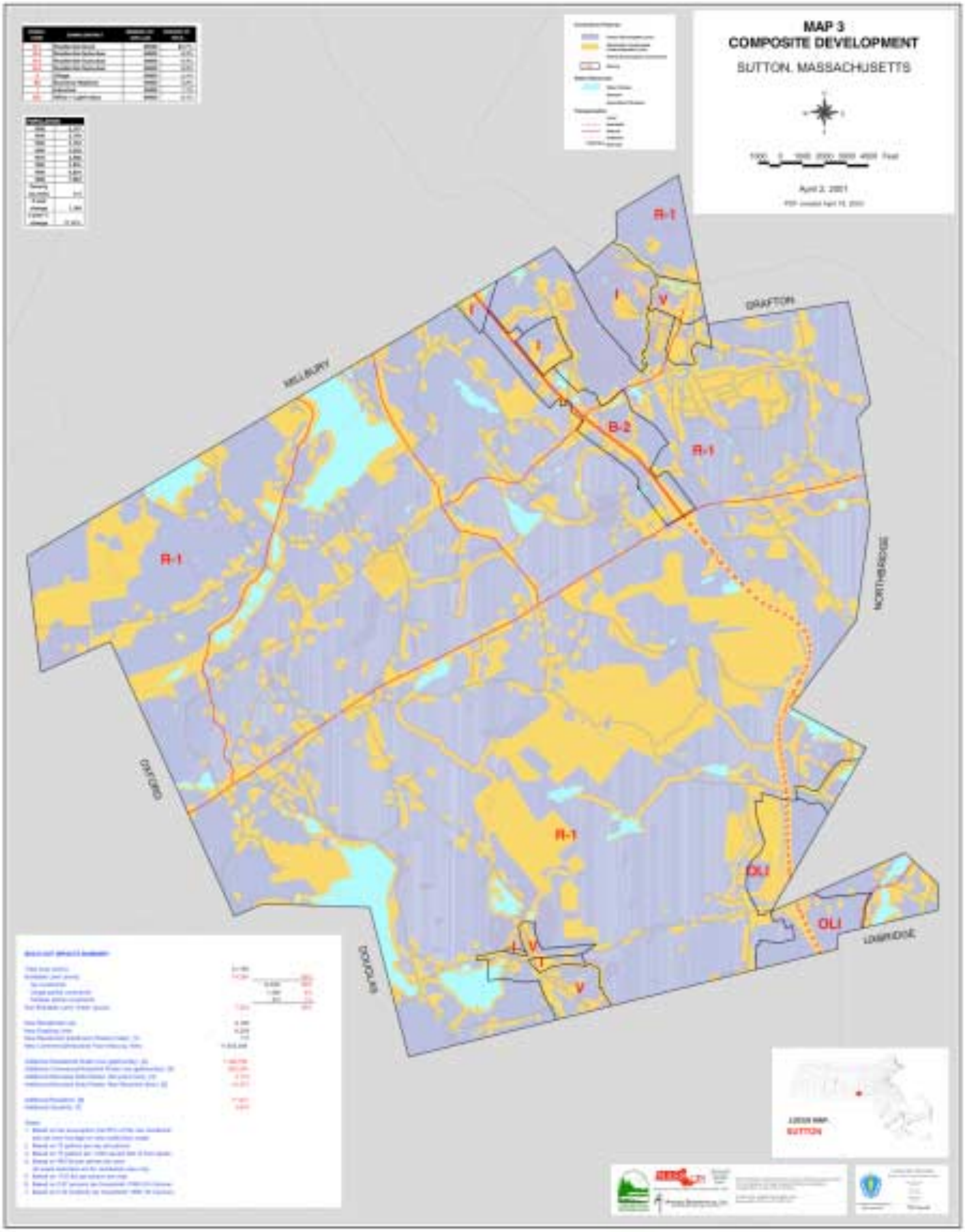
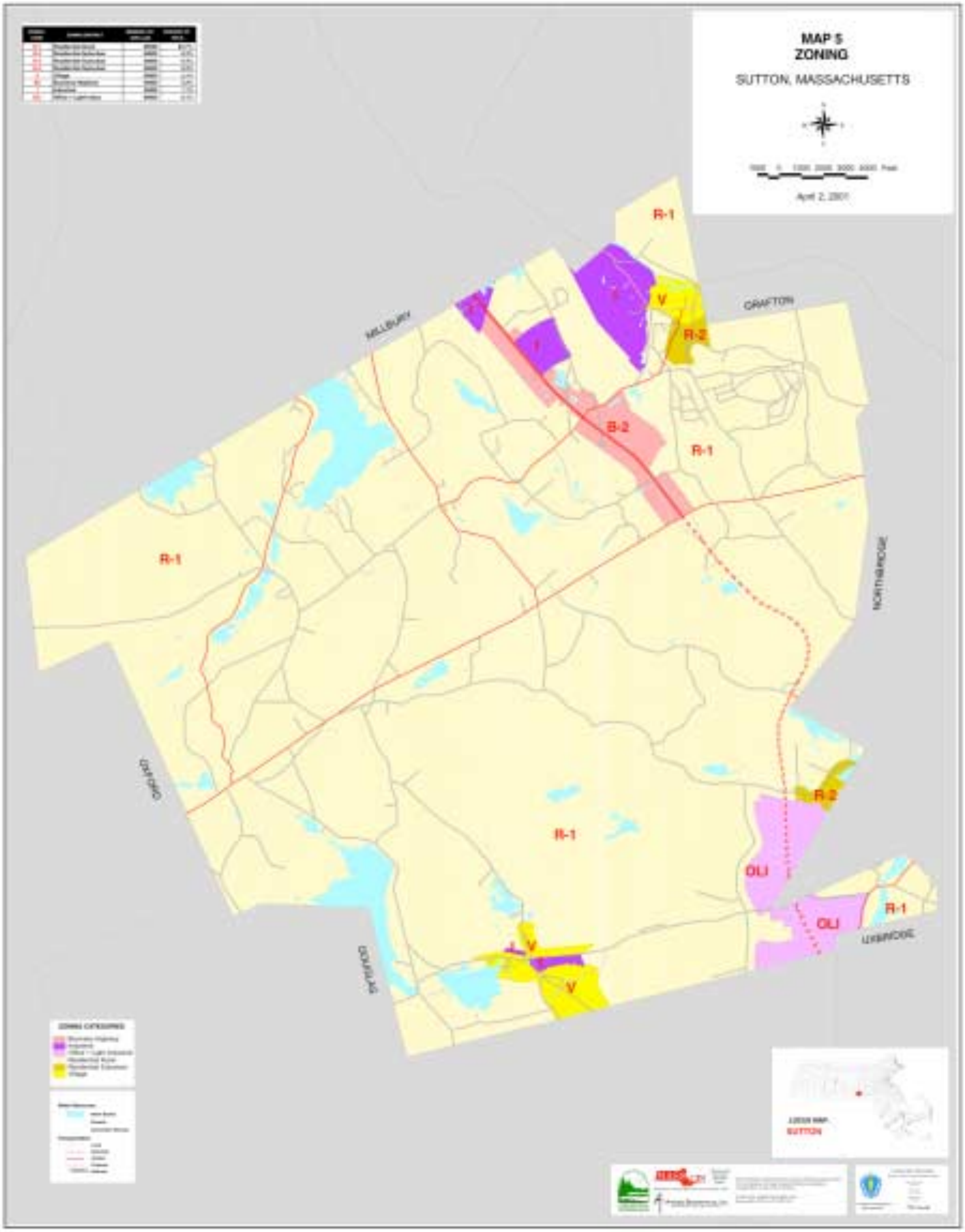


Figure 3-4: Zoning for Sutton, MA Buildout



Key Concepts & Systemic Problems

This section highlights key aspects of the buildout analysis' methodological structure and information requirements in order to develop an argument regarding why the procedures used have inherent, systemic drawbacks that can not be addressed without a major shift in the way organizations integrate information technology into their work.

By most accounts, the buildout analysis has been a qualified success in that it has brought growth management tools to every town in the state in a consistent way (Hodges, 2004). Most Massachusetts' towns are small and have almost no full-time government, let alone planning staff—yet home rule dictates that land use decisions be made at the local level. Combine this with the lack of any significant government structure at the county level, and the Commonwealth is left with a significant challenge to its ability to manage development. The buildout analysis tries to bridge this gap by presenting growth from the perspective of real land use policies, instead of abstract projections of trends in migration, job creation, housing policy and such. This strategy is powerful because it is based on the data, policies and regulations that towns control. But on the other hand, basing a model on real data and real laws creates the expectation that the model is integrated with those data and always up to date. This, of course, is where we want to be as a profession; but not where we are now.

Aside from the actual veracity of the model, some would say that the real purpose of the project has been to spur interest in land use planning and growth management. From a policy perspective this could lead to positive change without a buildout analysis leading directly to a change in zoning. However, it seems like a waste of money to simply use "scientific" analysis to generate interest in a topic. More attention must be paid to what it actually means to *use the buildout analysis to continuously inform an ongoing planning process*. In other words, if the project is able to spark a policy debate, it should be a useful tool in that debate and should continue to provide stakeholders with a means to develop knowledge out of the vast quantity of information we maintain about place during normal government operations.

What follows is a critique of the buildout analysis, despite the fact that it represents "good" planning analysis and mechanisms for stakeholder participation. It still suffers from a host of systemic problems in the way the study is designed and executed. These problems are so important because they are present in most planning support systems, so a close study of MassGIS Buildout should be useful as a general theory. The large, systemic issues highlighted here so that they may be addressed throughout the rest of this paper.

Simple math

The simplest aspect of buildout is the analytic methodology. The basic concept is to perform the type of site selection analysis that planners have used for decades (Lynch and Hack 1984). Instead of a single site, however, the analysis is performed for an entire town, being limited mainly by environmental constraints, which are determined in a manner which differs little from Ian McHarg's seminal overlay techniques (McHarg 1969).

So the analytic theory behind buildout is thirty years old, but so is the math. Areas to be developed are determined by cutting out unsuitable lands from the zoning map. This basic type of spatial overlay is what geographic information systems were created for in the 1960s. Buildout uses none of the latest techniques like spatial statistics or agent-based modeling. After developable areas are identified, the actual amount of development is determined by overlaying areas that impose partial constraints on construction. This concept is expressed as a potential construction percentage, between 0 and 100, and the maximum amount of development allowed by zoning is multiplied by this percentage. This part of the analysis could have easily been performed twenty years ago using Tomlin's map algebra language and software (Tomlin, 1983). But MassGIS chose to simplify it even further, by performing this step in a spreadsheet, so that the technical requirements are acceptable to virtually every person in the state.

Extensive data requirements, from multiple agencies

The buildout project's data requirements stand in stark contrast to the simplicity of the analysis. MassGIS has developed a large storehouse of GIS data for Massachusetts, especially pertaining to the natural environment. Buildout uses many of their statewide data sets, including open space, land use, aerial imagery, wetlands, flood plains, topography, areas of critical environmental concern, and roads. While most of these are developed, or at least edited by MassGIS, some come directly from federal government agencies such as USGS and Census. This information has all been put online in a single archival data format and documented formally. MassGIS has performed regular updates of their data warehouse and consistently maintained online access for years.

The creation of the zoning data set is unique in that zoning is created and controlled by each individual town. Especially in a home rule state like Massachusetts, it is difficult to translate every town's zoning regulation to a common standard, so the development of a statewide zoning layer is even more impressive.

The final data requirement is for the most recent subdivisions, which serve to update the land use plan with the latest development. Up to this point, we have had the involvement of a state GIS agency, one or two federal agencies, and the municipal zoning board. Subdivision data brings in the local assessors office, and may even require data from private developers, giving the project an information landscape that includes every type of data provider except for individual residents.

Zombie data

This might sound like a strange term to use in a scientific paper, but our profession currently has no term to describe this condition (and it is hard to solve a problem you can not name). Zombie data is not quite alive, because it has been detached from its native environment and is no longer being checked and updated. However, it is not quite dead because it is still being used in the way only living data should be.

Administrative agencies usually are the only ones with living data, and planners almost always have zombie data. For example, town assessors and registries of deeds have ownership and cadastral information; building departments have construction permits and new subdivision applications; and banks have the latest sales and loan-to-value ratios. But planners usually have old, out of date data sets that have a life of their own. Not only do these data sets get used in analyses, they move around in planning support systems, sometimes supplemented with additional calculations or personalized updates when they should have been replaced by fresh, live data a long time ago. And since they are not simply out of date, but may actually contain useful new information, they are even more difficult to put to rest and replace with an updated copy.

Often the issue is less of a methodological one, because an analysis based upon slightly out of date information is probably still sound. The larger issue is likely to be public confidence. Most people (in fact, anyone who did not construct the analysis) will not have the time or the inclination to understand the analysis well enough to know whether its results require the most up to date information. They will simply assume that outdated data equals an outdated analysis. So the problem of zombie data is threefold: It can invalidate the results of an analysis; it can make future updates difficult; and it can shake public confidence in the study.

In the case of MassGIS Buildout, the two data sets that are most susceptible to this problem are parcels and zoning. Property development is always one of the most dynamic data urban data sets, and when the study is about growth, new development is under an even brighter spotlight. The buildout analysis highlights the importance of accurate, current parcel information by discussing a number of ways to acquire it. There is no mention, however, of how to make the information gathering process replicable across towns, or over time.

Stakeholder participation

Oddly enough, the buildout system architecture does little to facilitate or encourage its stated goals. Just as strange is that this is not uncommon. Remember that the goal is to educate communities about the impact of unchecked development and motivate them to rationally plan for growth. The Community Preservation Act as a whole is able to work towards these goals, but the analysis piece is disconnected from the policy work.

The inclusion of stakeholders' concerns into the planning process is always mentioned as an important phase of the project, but what are we doing *methodologically* to facilitate this interaction? Is there any mention of how feedback is incorporated into the model, or at least the public record of the project? What is the project's public record anyway? The lack of attention to these questions is by no means unique to the buildout project. The two disciplines of analysis and collaborative decision making seem to always be holding each other at arms length. At this point the intention is only to draw attention to the concern, so that we may come back and address it later in the paper.

Interactive end-product

The standard deliverable from a project of this type is a bound paper report containing maps and tables embellished with plenty of explanatory text. The buildout analysis provides these for all 351 Massachusetts' municipalities, but two other more interactive end-products are also offered, putting the project on the leading edge of providing the public with participatory tools and transparency in government operations.

The first interactive end-product is accessed through the EOEA's Community Preservation Web site,

http://commpres.env.state.ma.us/content/buildout.asp. Here a visitor can create a regional buildout analysis by choosing any number of towns within a region. The site basically adds up the data for each town chosen on-the-fly. While this is computationally simple, it provides some limited ability to see what the aggregate impacts of development might be.

The second product may be downloaded from this Web site, but it must be run on one's own Windows™-based desktop computer. This product consists of the GIS data files used to create the "official" buildout analyses, plus proprietary scripts to reproduce the analysis. If an individual or group can meet the software requirements—ESRI ArcView GIS and Microsoft Excel—and has the technical capacity to use the software and understand the analytic methodology, all aspects of the analysis can be altered and re-generated (Jacqz, 2004).

For the sake of discussion, let's assume that all municipalities have easy access to ArcView, are skilled in its use, have in-house planning expertise, and have a complete understanding of all aspects of the modeling process. In this scenario, a town is able to take the analysis and update the base data to account for changes in zoning, new developments, open space acquisitions and such. In this way, the analysis for the town can always be up to date and accurate. They may also challenge some of the model assumptions and want to adjust variables like the average number of children per household, water and sewer usage, or automobile trip generation.

As you can see, the buildout analysis can be a powerful planning tool in the right hands. The first inherent problem with this utopian scenario is that most Massachusetts communities have no planning staff—professional or amateur—so it is highly unlikely that more than twenty to thirty of the state's 351 municipalities have the resources to contemplate making buildout analysis a regular part of their quarterly or yearly planning work.

The Community Preservation Act tries to address this by providing grant money to hire consultants, but these funds may only be available once or twice in a twenty year period, so the buildout analysis is likely to remain a static document. And while larger towns have the staff to use the buildout analysis, they are the most likely to ignore it because the methodology only allows new construction on undeveloped land. This works best in rural and suburban areas, which have little or no regular planning staff, not our dense cities like Boston, Framingham, Lawrence, New Bedford or Worcester, where new development will usually involve infill, or the replacement of pre-existing structures.

If the buildout analyses are to be used effectively by smaller towns, it will have to be through a partnership between towns and regional planning agencies (RPAs). But this brings data issues back to the forefront. Municipalities can not even share data across departments, let alone with another level of government, so we are left with a systemic mismatch between information flows, land use regulation and planning analysis. In my opinion, addressing this mismatch is one of the decade's great challenges for planning support systems.

Next steps

Major shortcomings in the Buildout analysis have now been identified. Information technology offers numerous solutions to those problems, which will all require tradeoffs in regards to cost, complexity and business process re-engineering. Therefore it is critical that the chosen solution be based upon sound theories describing the nature of the problem. This chapter developed those theories and showed their relevance to the Buildout analysis. Some strong suggestions were made regarding the problems technology should solve to move the profession forward. The rest of the paper presents one solution—a suite of technologies that conform to the theoretical foundation laid down here, and have the ability to fundamentally and structurally improve the efficacy of planning support systems.