

# ZONING PRACTICE

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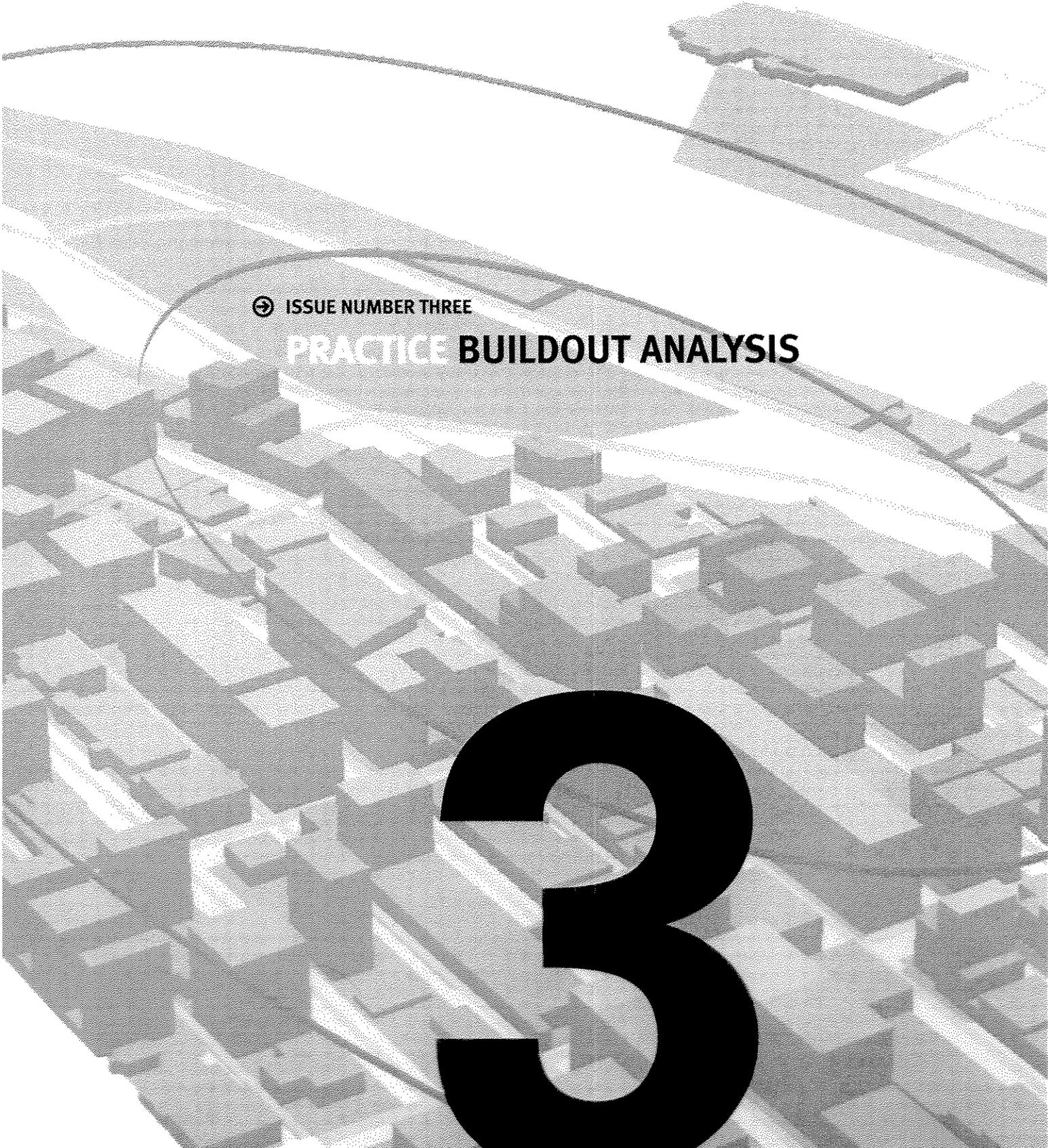
# FYI



⊕ ISSUE NUMBER THREE

## PRACTICE BUILDOUT ANALYSIS

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# Buildout Analysis: A Valuable Planning and Hazard Mitigation Tool

By David R. Godschalk, FAICP

Anticipating the likely impacts of future development on livability and safety is an ongoing challenge for local planners and emergency managers.

How can you translate those symbols on the future land-use map or the zoning map districts into potential impacts on hazard vulnerability, community livability, and infrastructure capacity? One approach is to conduct a buildout analysis in order to generate a future growth scenario of full development.

Buildout analysis is a useful tool for planners and emergency managers who wish to anticipate the impacts of future development. Buildout analysis looks ahead to the planning horizon in order to project the amount and location of growth allowed under existing community development policies. Its findings can be used to assess the resulting impacts and to ask whether current plans, development regulations, and hazard mitigation strategies should be reconsidered.

## WHAT IS BUILDOUT ANALYSIS?

In its basic form, buildout analysis simply asks: What is likely to happen if the community grows to the full extent allowed under present development regulations and plans? It says: Let's assume that all the growth permitted under our future land-use plans or zoning comes to pass, then look at the outcome and see if we believe that the resulting development pattern is desirable or needs to be changed.

Buildout analysis may be based on land parcels or zoning districts. In either case, the analysis will be facilitated by the use of geographic information system (GIS) maps and overlays. A *parcel-based analysis* examines each parcel to determine its maximum feasible future development. A *zoning district analysis* looks at the aggregate of developable land in each zoning category, based on photo-interpretation of land use and ignoring parcel boundaries.

## HOW IS BUILDOUT ANALYSIS USED?

The basic purpose of buildout analysis is to translate technical planning and regulatory materials into a long-range growth picture or scenario that can be understood by local decision makers to help them evaluate potential impacts and discuss possible alternatives.

Impacts can be expressed in terms of the number and location of new housing units, the amount and location of new commercial or industrial square footage, the size of the new population or some portion of it—such as the number of new school-age children, the additional gallons per day of water demand, the length of new roads, and the like. To affect or mitigate the impacts, planners can explore alternatives such as amendments to the future land-use plan, zoning ordinance, floodplain maps, or environmental protection policies.

Local and regional growth managers can use buildout analysis to assess the desirability of future land-use patterns and the adequacy of infrastructure and capital improvement programs. Jurisdictions with

urban growth boundaries can use buildout analysis to compare the capacity of designated growth areas with projected population demands. Emergency managers can use buildout analysis to project the vulnerability of future development to natural hazards. Communities concerned about maintaining their quality of life or sustainability can use buildout analysis to construct visions or scenarios of future conditions.

Applications of buildout analysis can be found in a number of jurisdictions.

Mecklenburg County, North Carolina, applied buildout analysis in combination with HAZUS modeling (see sidebar) to project the impacts of development on flood hazard areas and vulnerability. The state of Massachusetts applied buildout analysis to encourage all of its cities and towns to look to the future and consider policy changes to preserve and enhance their quality of life. The Massachusetts Audubon Society applied buildout analysis to assess the impacts of sprawl.

## WHAT IS HAZUS?

HAZUS-MH is a powerful risk assessment software program for analyzing potential losses from floods, hurricane winds, and earthquakes. In HAZUS-MH, current scientific and engineering knowledge is coupled with the latest Geographic Information Systems (GIS) technology to produce estimates of hazard-related damage before, or after, a disaster occurs. HAZUS-MH takes into account various impacts of a hazard event, such as:

- physical damage: damage to residential and commercial buildings, schools, critical facilities, and infrastructure;
- economic loss: lost jobs, business interruptions, repair and reconstruction costs; and
- social impacts: impacts to people, including requirements for shelters and medical aid.

Source: Federal Emergency Management Agency website at [www.fema.gov/hazus/index.shtml](http://www.fema.gov/hazus/index.shtml).

## ASK THE AUTHOR JOIN US ONLINE!

From April 3 to 14, go online to participate in our "Ask the Author" forum, an interactive feature of *Zoning Practice*. David R. Godschalk, FAICP, will be available to answer questions about this article. Go to the APA website at [www.planning.org](http://www.planning.org) and follow the links to the Ask the Author section. From there, just submit your questions about the article using an e-mail link. The author will reply, and *Zoning Practice* will post the answers cumulatively on the website for the benefit of all subscribers. This feature will be available for selected issues of *Zoning Practice* at announced times. After each online discussion is closed, the answers will be saved in an online archive available through the APA *Zoning Practice* web pages.

### About the Author

David R. Godschalk, FAICP, is an emeritus professor of city and regional planning at the University of North Carolina at Chapel Hill and a coauthor of the fifth edition of *Urban Land Use Planning* (University of Illinois Press, 2006).

### MECKLENBURG COUNTY FLOOD HAZARD ANALYSIS

Mecklenburg County, including the city of Charlotte, wanted its citizens to be aware of their exposure to flooding. In 1999, they invested federal, state, and local funds in updating their flood maps. The new maps show not only where the floodplain is currently but also where it will be when the area is completely developed.

To replace its out-of-date floodplain maps, which FEMA created in 1975 using predicted 1995 land use, the county used hydrologic/hydraulic computer models to develop new maps based on current (1999) land-use and watershed data. These maps became the official FEMA Flood Insurance Rate Maps (FIRMs). FEMA, however, does not draw floodplain maps based on future land use. The county therefore used buildout analysis to prepare local Floodplain Land Use Maps (FLUMs) to limit new development in the *future* flood hazard area.

County planners derived ultimate buildout from local district plans to create GIS coverages of future land use. They added these into the hydrologic/hydraulic computer models and computed new flood elevations and floodplain areas. They then prepared revised zoning and stream setback regulations to ensure the safety of future development, including a minimum base flood elevation, or "freeboard," of one foot above the projected future flood height.

In order to build community support for adopting the Future Conditions Floodplain maps and new regulations, the county decided to quantify the benefits of the new approach in terms of potential flood losses avoided. In 2000, the county hired a consulting team to use the HAZUS Flood Loss Estimation Methodology to compare estimates

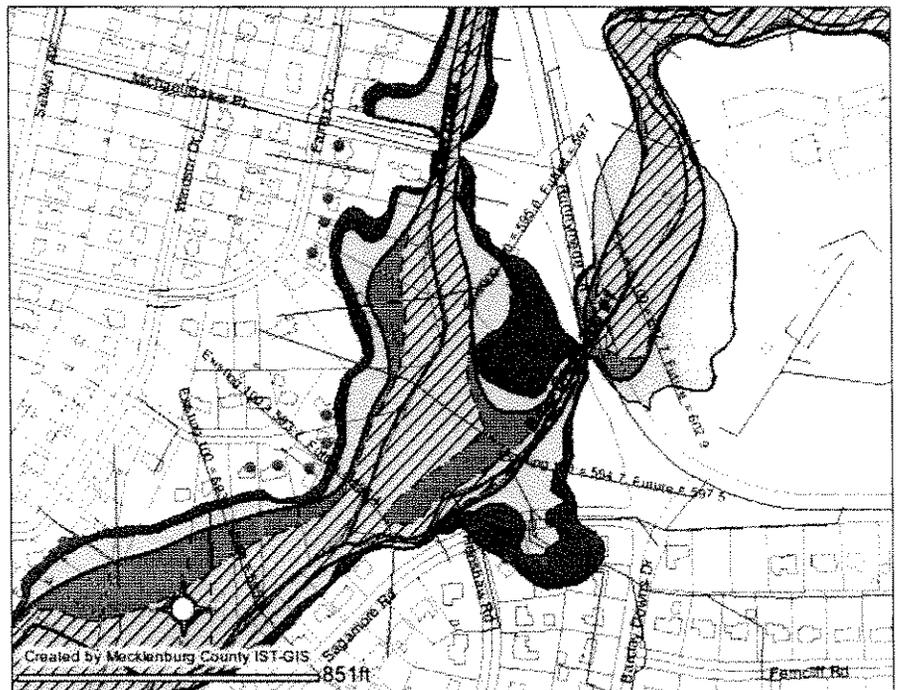


Figure 1. The FEMA floodplain (flood insurance required) is shown in light shading. The Future Conditions Floodplain (local regulations apply, but flood insurance is not required) is shown in dark gray. This FLUM is available in color on the county website, <http://maps.co.mecklenburg.nc.us/website/floodzone>.

of potential flood damage under the new FEMA maps and the FLUMs.

The results were convincing. The analysis found that using the new maps and regulations would avoid losses to building content and structures of up to \$333 million. These appear in Figure 2 on page 4.

- The first run combined current land use and the 1975 floodplain. It calculated a potential loss of about \$213 million.

- The second run combined the current land use with the FEMA Year 2000 Floodplain. It calculated a loss of about \$318 million.

- The third run combined the land use at buildout and the Year 2000 Floodplain. It calculated a loss of about \$651 million.

The difference of some \$333 million between the second and third runs persuaded the local leaders that it would be wise to

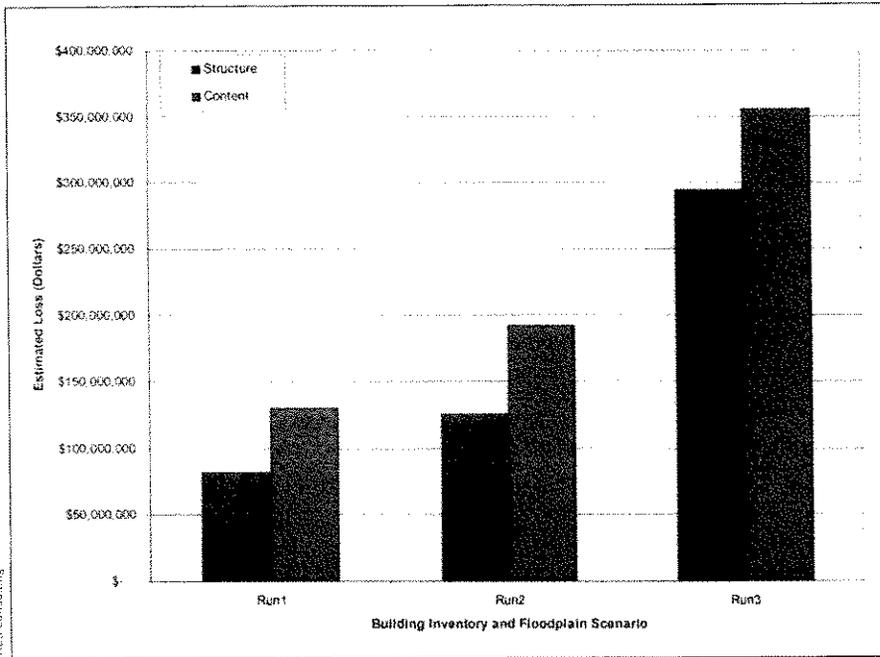


Figure 2. The three runs of the damage estimation model are shown; the left bar in each represents losses from building content, the right bar structure damage.

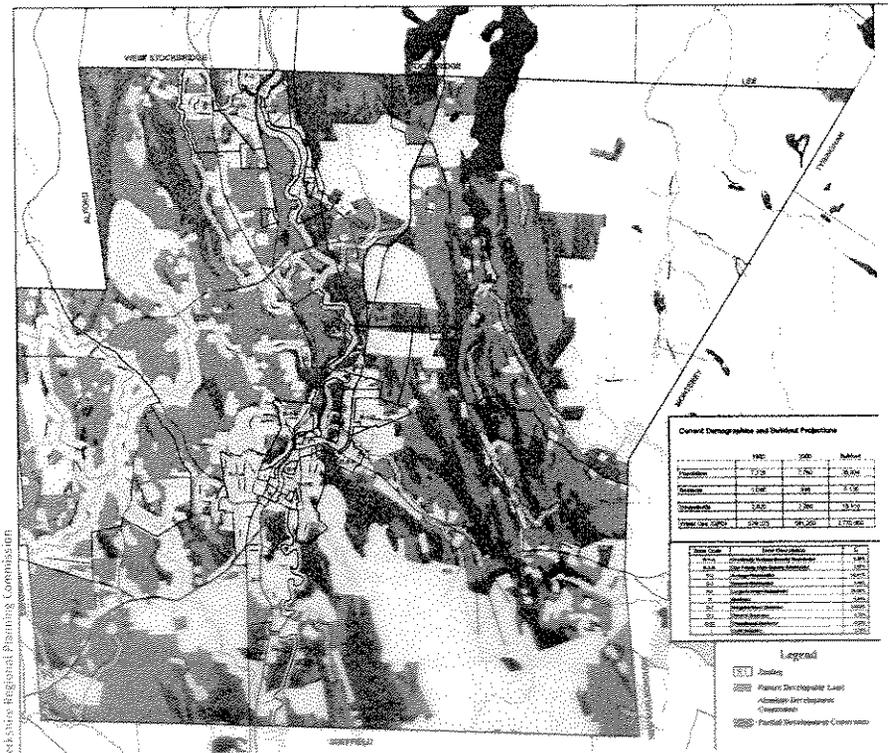


Figure 3. GIS Map of Greater Barrington, Massachusetts, showing developable land (grayish areas), partial constraints (darkest), and absolute constraints (light color).

adopt the new maps and regulations in order to keep future development out of harm's way.

### MASSACHUSETTS STATEWIDE BUILDOUT ANALYSIS

The state of Massachusetts completed buildout analyses for all of its 351 communities in 2002, as part of the Community Preservation Initiative of the Executive Office of Environmental Affairs. Outputs of the analyses included number of housing units, population and number of school children, square feet of commercial and industrial space, gallons of water demand, and miles of roads. These analyses were presented to local decision makers to help them evaluate potential impacts of future development and to create a receptive environment for discussion of alternatives such as zoning changes, open space protection, and regional cooperation.

MassGIS—the state geographic information agency—provided developed land-use data. Analyses were conducted by regional planning agencies and consultants. Undeveloped land in each zoning district was identified through interpretation of orthophotographs (photographs prepared from perspective photographs by removing distortions and displacements of points caused by tilt, relief, and perspective), ignoring parcel boundaries. Using overlay and spreadsheet tools, standard formulas were applied to generate yields of future residential units and commercial/industrial areas. The state provided a buildout analysis methodology and scope of services for contractors. Because the Office of Environmental Affairs contracted in bulk for the buildout analyses for the entire state, there were significant economies of scale and each buildout map series cost only \$7,000 per community.

By using a consistent methodology and set of land-use categories, the buildout analysis maps could be aggregated across regions. The Office of Environmental Affairs held meetings in five high-growth regions to show composite regional buildout maps and to facilitate discussions of coordinating regional growth management efforts.

In addition to community orthopho-

tographs and zoning districts, the Massachusetts map products include:

- **Zoning and Absolute Development Constraints Map:** Absolute development constraints include permanently protected open space and other no-build areas.
- **Developable Lands and Partial Constraints Map:** Partial constraints include wetlands or floodplains that can be included in gross building lot minimums (even though not built on), soil types that limit development due to poor drainage, and the like.
- **Composite Development Map:** A visual summary showing developable lands and developed or protected lands, along with a chart summarizing potential impacts at buildout.

For example, the composite development map (Figure 3) for the town of Great Barrington depicts the pattern of future developable land, the land with absolute development constraints, and the land with partial development constraints. The map also includes three tables: the percentage of land in each zoning district, current demographics and buildout projections comparing buildout values with those from the year 1990 and 2000, and summary of buildout impacts.

#### MASS AUDUBON SPRAWL ANALYSIS

The Massachusetts Audubon Society used buildout analysis and U.S. Census housing permit data to illustrate two “sprawl frontiers.” They found high levels of development in areas of relatively low buildout west of I-495 and in lower southwestern Massachusetts. This combination of high rates of construction with relatively unbuilt land acts as a sprawl frontier pushing its way west and southeast across the state (see Figure 4). While high construction levels on Cape Cod proceed despite a high level of buildout there, this was attributed to ongoing infill and teardown development.

#### CONDUCTING A BUILDOUT ANALYSIS

Buildout analysis can be done manually or on a computer. The use of hand-drawn overlays to show what a landscape could look like and mathematical calculations to tabulate what its resulting population could be is described in

Jeff Lacy’s *The Manual of Build-Out Analysis*. The use of a GIS computer mapping program and a computer database and spreadsheets increases the efficiency and consistency of buildout analysis, as described in the Massachusetts buildout program.

Localities considering conducting a buildout analysis need to ask themselves a number of questions. How would they use a buildout analysis? What method is best suited to their needs? What data are available?

future problems); the level of detail needed (e.g., a parcel level or a zoning district level, only residential development or all development); and the time period to be studied (e.g., complete buildout whenever that occurs or the level of buildout at some future periods, such as 10- or 20-year increments). For example, Mecklenburg County analyzed the areas adjacent to its streams because it was concerned with the impact of future development on flooding. It used parcel-level data, which were needed as inputs to the flood

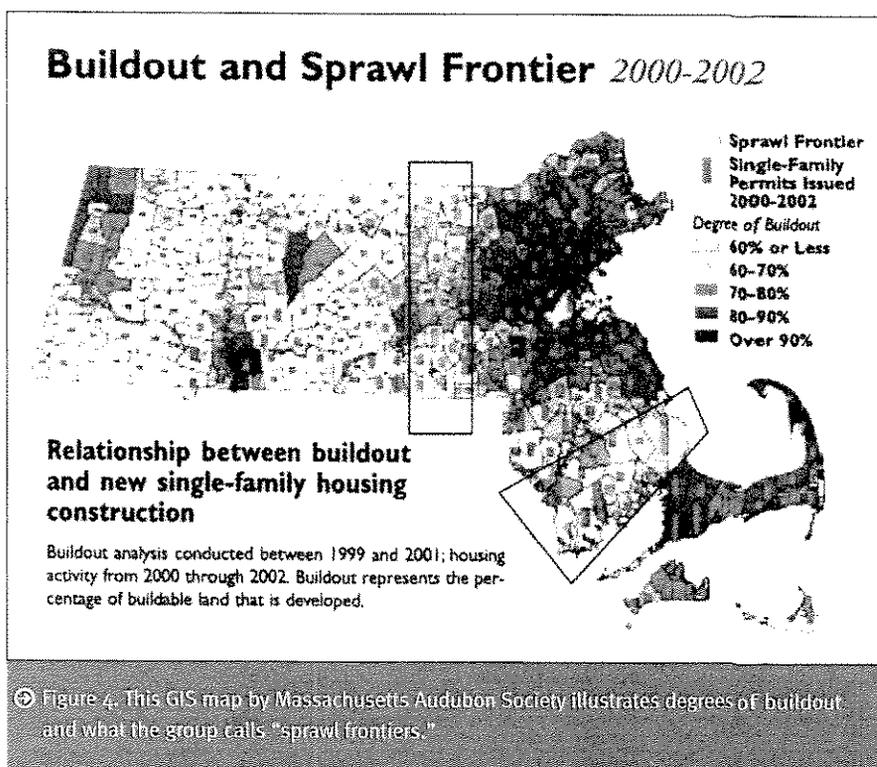


Figure 4. This GIS map by Massachusetts Audubon Society illustrates degrees of buildout and what the group calls “sprawl frontiers.”

#### EXPECTED USE

Buildout analyses can be used to assess and amend development regulations, including zoning and subdivision ordinances, which may contribute to the potential of future disasters. They can be used to revise a comprehensive plan in order to build consensus on an alternative vision of the future community. They can be used to create a greenprint plan based on an assessment of the potential damage to natural systems from projected development.

The desired use will influence the analysis area (e.g., the whole jurisdiction or only a portion where development is likely to cause

model and the HAZUS model. It looked at full buildout under its adopted district plans.

#### SUITABLE METHOD

Choosing a suitable method for a buildout analysis will involve issues such as the staff, time, and budget available to carry it out. Buildout analyses can be relatively simple or very complex. Whether they are done manually with hand-drawn overlays or with a computer-based GIS program will depend upon staff competencies.

The U.S. Environmental Protection Agency’s Green Communities program lays out the procedure for a simple manual buildout

## Providing a standard, regionwide set of land-use classes and a consistent methodology can produce more efficient and affordable buildout analyses.

analysis, in which possible development lands are overlaid on a community base map and the relevant changes in impervious surface, population, housing, and the like are calculated.

The Massachusetts Community Preservation Initiative lays out a procedure for a simple zoning district buildout analysis using a GIS computer program. A more complex parcel-based buildout analysis for Charlestown is described in Matthew Amengual's 2001 Brown University land-use thesis, available at <http://envstudies.brown.edu/Thesis/2001/amengual/index.html>.

No matter how the analysis is conducted, there are two stages in the process. Stage 1 depicts the existing development and projected development changes on maps. Stage 2 calculates the quantitative impacts of the changes and summarizes the critical information in tables.

### **Stage 1. Development map preparation.**

The *existing development* base maps should depict:

- community boundaries
- existing roads and land use
- existing zoning districts
- permanently protected or constrained open space
- partially constrained lands (e.g., steep slopes, floodplains, wetlands, utility easements, public ownership)
- recent subdivisions.

For a manual analysis, these maps will be separate overlays; for a GIS analysis, these maps will be separate digital layers.

The *projected development change* maps should depict:

- undeveloped areas (e.g., vacant buildable land with no constraints)

- underdeveloped areas (e.g., land that contains significantly less density or intensity of use than allowed, such as a single-family house on farmland or on land zoned for commercial use)
- possible infill areas (e.g., neighborhoods or commercial districts with the potential for increased density or intensity through use of vacant lands or redevelopment of lower-intensity areas)
- a composite map of all future development area potential at buildout.

**Stage 2. Quantitative analysis.** Moving from the potential development areas to quantities of housing units and of commercial and industrial square feet, or the project buildout "yield," requires the calculation

of a number of factors that affect the net yield.

For *residential units*, deductions for roads, lot size variations, and other constraints can subtract 10 to 30 percent from potentially buildable acreage. The result is total net buildable area, expressed as the formula:  $Raw\ Land \times Adjustments\ (for\ roads\ and\ other\ constraints) = Total\ Net\ Buildable\ Area$ . The net buildable area is then divided by the minimum lot sizes required in the various residential zones to find the total number of new housing units.

For *commercial and industrial areas*, the analysis is based on determining an "effective FAR" (Floor Area Ratio) that takes account of zoning requirements and limitations. Typical limiting factors include the FAR or the percent lot coverage and height limits specified in the zoning ordinance, along with parking and open space requirements. To avoid overestimating the potential square footage, the effective FAR should be based on the most limiting of the requirements. This calculation requires professional judgment and knowledge of the community to select realistic mixes of alternative future land uses within each zoning district.

### RESOURCES

- ABS Consulting. 2003. *Determination of Financial Impacts from Flood Studies*. Mecklenburg County Water and Land Resources Division. Final Report. Prepared for Mecklenburg County Engineering & Building Standards: Charlotte, N.C.
- Berkshire Regional Planning Commission. [www.berkshireplanning.org](http://www.berkshireplanning.org).
- Charlotte Mecklenburg County Government. Countywide Floodplain Remapping Project. <http://charmeck.org/Departments/LUESAWater+Land+Resources>
- Lacy, Jeff. 1990. *The Manual of Build-Out Analysis*. Amherst: Center for Rural Massachusetts.
- Mass Audubon 2003. *Losing Ground: At What Cost?* [www.massaudubon.org/losing-ground](http://www.massaudubon.org/losing-ground).
- Massachusetts Executive Office of Environmental Affairs. [www.mass.gov/envir](http://www.mass.gov/envir).
- Massachusetts Geographic Information System (MassGIS). "Scope of Services for Buildout Analysis." [www.mass.gov/mgis/buildout.htm](http://www.mass.gov/mgis/buildout.htm).
- Massachusetts Geographic Information System (MassGIS). "GIS-based Buildout Analyses for All the Cities and Towns in Massachusetts." [www.mass.gov/mgis/mgpres2.htm](http://www.mass.gov/mgis/mgpres2.htm).
- U.S. Environmental Protection Agency. Green Communities Program. [www.epd.gov/greenkit/build\\_out.htm](http://www.epd.gov/greenkit/build_out.htm).

Finally, *multipliers*, based on existing demographic and public facility data, can be used to derive impacts of buildout development for each new residential unit or each increment of commercial or industrial square footage. These multipliers can include increases in projected future population, future additional school students, future demand for water supply or sewage treatment, as well as potential tax revenue and service costs.

#### DATA AVAILABILITY

An important consideration in planning a build-out analysis is the availability of data. In the ideal case, the community will have digital versions of its zoning, existing and future land use, roads and transit, wetlands and floodplains, open space, orthophotographs, and recent development maps, as well as natural hazard areas, and parcel and tax assessment maps. In many cases, however, much of this information will be unavailable or out of date and will have to be supplemented and updated.

The availability of data can be a major budget constraint. In order to realize economies of scale, regional planning agencies can coordinate data needs for a number of communities. Providing a standard, nationwide set of land-use

**WEB ENHANCEMENTS**

All four figures are reproduced in color on the *Zoning Practice* web pages. In Figure 1, the FEMA floodplain (flood insurance required) is depicted in light blue. The Future Conditions Floodplain appears in dark gray. This FLUM map is available on the county web site, <http://maps.co.mecklenburg.nc.us>.

In Figure 2, the losses from building content are in blue and from structure damage in green.

Figure 3 depicts the pattern of future developable land in blue gray, the land with absolute development constraints in yellow, and the land with partial development constraints in light red.

classes and a consistent methodology, as in the Massachusetts case, can produce more efficient and affordable buildout analyses.

#### CONCLUSION: THE PAST, PRESENT, AND FUTURE OF BUILDOUT ANALYSIS

Buildout analysis is the most recent incarnation of such venerable planning tools as carrying capacity analysis and cumulative impact

analysis. It takes the principles of these earlier efforts at integrative, forward thinking into the present era of geographic information systems and computer-based analyses. At the same time, buildout analysis makes these earlier methodologies more widely accessible by deriving operational methods for injecting the resulting scenarios of development impacts into participatory planning and visioning.

Such a useful tool is bound to expand the effectiveness of planning programs, scenario construction, and citizen involvement in goal setting. It is not difficult to imagine buildout analyses becoming standard, required elements of all growth management, natural hazard mitigation, and future land-use plan making.

Cover graphic: ArcGIS 3D Analyst software was used to depict the maximum allowable building envelopes permitted under the development regulations of Tacoma, Washington's "Destination Downtown" code for primary and secondary "transit impact zones," the potential development influence areas surrounding the northern terminus of the recently built light rail line. The 3D map analysis was done by Heather Jones, GIS Analyst. Copyright City of Tacoma, Community and Economic Development Department.

## **Don't Miss These Zoning Practice-Sponsored Sessions at APA's 2006 National Planning Conference** April 22-26 in San Antonio

### **The Principles of Smarter Development Review** Monday, April 24, 11:00 a.m.-12:15 p.m.

How do organizational culture, agency management, and a results-oriented approach combine to cut through bureaucracy and make for smarter development review? Find out how cities as varied as Milwaukee; Aspen, Colorado; and Irvine California, have established an environment for review and decision making that meets community goals and achieves great projects.

### **Market and Economic Feasibility Considerations for Zoning Professionals** Monday, April 24, 1:30 p.m.-2:45 p.m.

Learn how market and economic feasibility analysis can inform zoning efforts. The growing popularity of such tools as design guidelines, form-based codes, and discretionary design review suggests increased interest in carefully controlling development to achieve specific goals. As this focus on guiding and harnessing market and economic forces becomes more prevalent, learn why planners should consider these underlying forces and the potential interactions with regulations.

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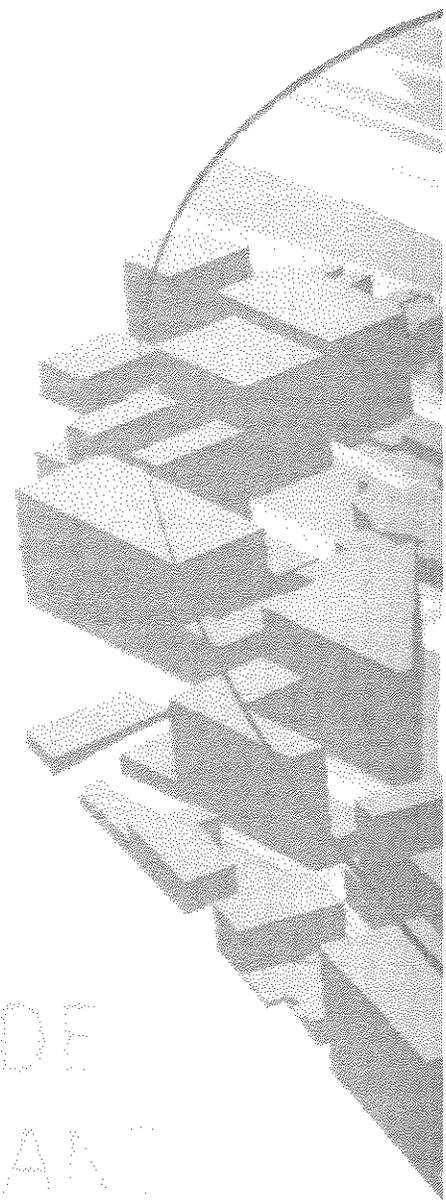
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