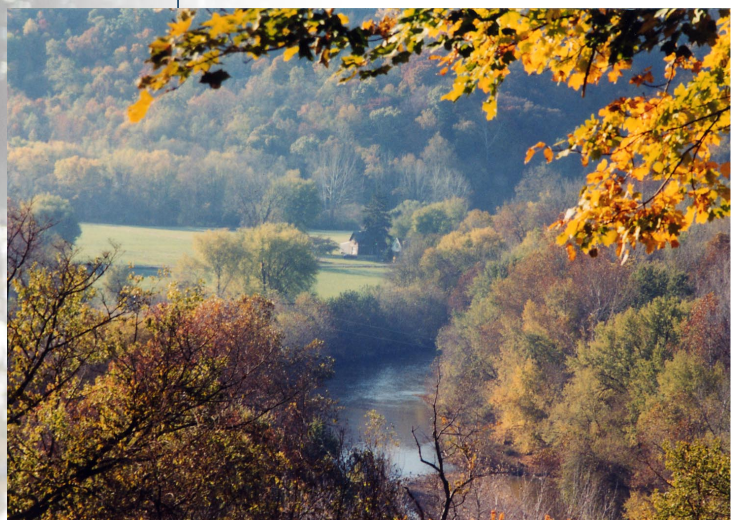
Learning from the Application of Land Use Change Models



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Workshop Introduction and Summary

Lawrence W. Libby
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This is the third of five annual workshops on the general theme of agro-environmental policy issues in the Great Lakes Region. The series is underwritten by a grant from the U.S. Environmental Protection Agency with additional support by The Ohio State University, Michigan State University, The Elton R. Smith Endowment in Food and Agricultural Policy at MSU and the C. William Swank Program in Rural-Urban Policy at OSU. The first of the three workshops dealt with the role of science and scientists in public policy, the second focused on rural water quality and the importance of "total maximum daily load," and this year we shift to the role of land use models in land use policy. Each workshop is put together by a planning committee specific to the topic, with co-chairs and co-PIs Sandra Batie from MSU and Larry Libby from OSU organizing the process. Committee members for this workshop are listed on the inside cover of the report.

The enormous complexity of understanding and dealing with land use change has encouraged planners and policymakers to seek formal analytical systems that can incorporate data from various sources. These models help people visualize the effects of land use trends, population and economic dynamics at the present and project them into the future. Land use models are designed with various needs in mind. Some model builders are enamored with the shear elegance of the models themselves. The ability to visually portray the land use pattern that may result from the various factors affecting competition for land is impressive in its own right. Our focus here, though, is on the utility of those models – how they may inform the policy process. Major impetus for this workshop theme came from the recent EPA report "Projecting Land Use Change: A Summary of Models for Assessing the Effects of Community Growth and Change on Land Use Patterns."

Conceptual underpinning for land use models comes from several disciplines – geography, economics, planning, demography and others. Data sources and priority will vary accordingly among the disciplines. Workshop participants included university and consultant researchers from several institutions and disciplines, planners, extension educators, students, policymakers and implementers.

Two speakers served as keynoters to set the stage for discussion of specific models and applications. First was ***Keith Clarke***, Chair of the Department of Geography at the University of California, Santa Barbara. He presented a well-organized and complete primer on land use modeling, reviewing the key challenges in developing reliable modeling systems drawing on the relevant disciplines. He discussed the spatial and temporal dimensions of land use models, from Von Thunen to the present. He presented the central features of nineteen specific models with roots in economic geography and emphasized the added strength of integrated systems of these analytical tools.

Mark Wyckoff, President of Planning and Zoning Center, Inc., in Lansing, Michigan and a long-time participant in land policy debates in that state was the second keynoter. Mark emphasized the many challenges of putting these sophisticated models to work on real policy problems. First is the issue of credibility. Will people whose opinions matter trust the often mysterious workings of these computer-driven "black boxes" or will they doubt that any crunching of numbers based on history can tell us anything reliable about a particular place in the future? Can these formal perceptions of alternative futures really lead to a better decision than available from less structured observation and judgment? Political leaders recognize that information is power. Few are ready to yield to computers without a strong element of skepticism. Model building requires abstracting from the impossibly complex reality of day-to-day land use choices. Some will worry that the inevitable loss of information in building the abstract representation of the real world will make the result less than satisfactory. Another key point – visualization of change patterns is powerful. The ability of a planner or analyst to show how things may look in the future if current trends continue sends a clear message that helps people form judgments. Reliance on models as representation of "truth" may lead to what Wyckoff has termed "modeloholics" who can't seem to survive without more and more models. Withdrawal from such dependency can be painful, he suggests.

Next, the workshop moved to consideration of specific models and/or applications. ***Tim DeWitt*** and ***Dale Bertsch*** explained their application of the Land Evaluation/Site Assessment (LESA) model developed by USDA for helping set land use priorities in Fairfield County, Ohio. The LESA input data are integrated with other demographic information to help local decision-makers identify areas with best potential for farm production and other areas where development may be more appropriate. Then these model results were linked to the interests of local residents in several public meetings held throughout the county. The point here is that application of sophisticated modeling to real decisions is a process more than a product. The product is necessary, but will have little effect without careful communication.

Brenda Faber from Fore Site Consulting, Inc. then presented the essential features of the *CommunityViz* model, applied in this instance to a national forest in Colorado. This specific application addressed the implications of alternative management strategies for multiple uses in the forest. The model also enables the analyst to project the consequences of simulated policy alternatives for a given set of resources. Built on a Geographic Information System (GIS) framework, the model is a useful visualization of the "so what" consequences of possible futures for a specific area. A 3D enhancement capability further helps people see what the future may look like. Many communities throughout the U.S. have used the model in their planning.

Tom McClintock's perspective of model application is to assemble models from any available source and link them together for the needs of a specific community. His role with the Land Information and Computer Graphics Facility at the University of Wisconsin is to work with individual community clients, in this case the city of Verona in Dane County. Community needs and expectations dictate the model design. The WhatIf? planning support system helps decision leaders consider the implications of alternative development scenarios with visual displays.

State level transportation planning was the context for land use modeling presented by ***Sam Batzli*** from Michigan State University in collaboration with regional transportation planner ***Dennis Kent*** from the Michigan Department of Transportation. Focus in this modeling application is on U.S. 31 between Holland and Grand Haven, Michigan. The challenge is to consider the traffic implications of population growth projections and design a road improvement that meets the transportation needs without undue environmental and social impact. Citizen involvement is key in this case as people try to visualize the likely causes of change in that area.

Broader, more comprehensive policy design is the thrust of land use modeling being directed by ***Bill Rustem*** of Public Sector Consultants, Inc. in Lansing, Michigan. The central question in this work is the impact of projected population settlement patterns on Michigan's land-based industries – agriculture, forestry, mining and tourism. Various simulations enable the analysts to identify most critical points of conflict in the competition for the state's open lands. Fragmentation causes much of the problem. More than the actual change in use on specific parcels, fragmentation of lands reduces habitat and critical mass for farming and forestry. When people are dispersed throughout the landscape on small rural parcels, the future of those areas is in real doubt. This impermanence syndrome has long term and somewhat predictable consequences for land use patterns.

Pat Norris, Department of Agricultural Economics faculty member from Michigan State, concluded the workshop with a discussion of key findings. Discussion surrounding each presentation was spirited and substantive with the central points summarized in this report. Dr. Norris reinforced those findings with her wrap-up comments. The over-riding conclusion seems to be that models can augment, but not replace, informed judgment by the diverse publics who have a stake in land use change. There is no "optimum" land use pattern in the real world, but a series of competing definitions of best use. Models can sharpen the terms of debate, giving better evidence of the trade-offs between land uses and competing visions of the preferred future for an area. Modeling and modelers have an important role to play in land use change policy. Ever-improving modeling technologies can bring remarkable clarity and insight to policy debates. Enabling people to actually see the implications of alternative futures is powerful indeed. But no modeler should expect the elegance of their work to yield instant (or even long term) consensus. And no local policymaker should dismiss the strength of models to sharpen intuition. The best we can expect is a more substantive basis for incremental policy change.

Modeling Land Use Change

Keith Clarke
Chair, Department of Geography
University of California, Santa Barbara

Land use describes the way in which people interact with the land. This is distinct from land cover, which is the type of vegetation or natural feature that distinguishes the land. Land use change is defined as the encroachment of one type of land use into an area formerly used for something else, e.g., an urban residential area into open land.

Land use change has a temporal aspect in that different changes involve different amounts of time. Most land use transitions are slow and cumulative. We do not see the change until it has already occurred. And we do not notice incremental changes, which can be subtle even when viewed with a map.

A large amount of effort has gone into mapping land use. There have been major efforts made at the local level. Some efforts have been made at the state scale but very little has been done on a global scale. Land use is a human process and we bring cultural values into mapping land use.

Land use change modeling variables include drivers, state probabilities, class magnitudes, spatial autocorrelations, and feedbacks.

Ultimately we have to think about processes and how they are occurring in the landscape. Some drivers of land use change come from the growth of human settlements and civilizations. One recent paper used statistical methods to determine the drivers of land use change from the observed pattern of change.

Land use states are categories into which we group land uses (e.g., water, forest, agriculture, etc.). It is important to remember that these are use states. The forest in a park is different from a forest outside a park. Measuring state change requires at least two maps to represent state transitions, and changes may be static or dynamic so require more temporal coverage.

Land classes may differ in the magnitude with which they occur on the landscape. We usually think of a background class such as agriculture that is dominant in the landscape. Some of the most dynamic classes are under-represented in the landscape.

Spatial autocorrelation refers to the idea that things that are near to each other are much more related than things that are far from each other.

Feedbacks occur when one type of land use conversion precipitates another type of land use. For example, a positive feedback may be conversion from residential to commercial land. A negative feedback may be conversion from residential to a toxic waste facility.

All of these variables need to be considered when dealing with land use change.

Regional patterns of land use change can be persistent. A transition from wildland to agriculture occurred in the nineteenth century in Southern California. Land changed from forest to agriculture in the eastern United States, and all over the world. Wetlands have been converted to agriculture more commonly than we might think. Agricultural land has been converted to urban lands, which is the story of the twentieth century. Residential converted to commercial land is the Burgess model "Zoning Transition" and occurs as cities grow. Agriculture converted from forest has been the dominant land use in the United States for the last hundred years.

In terms of recent national trends, there has been a regain of forestland in the eastern United States. There has been a conversion of wildland to agriculture in the western U.S., while forests have been lost to agriculture in Wisconsin.

There remain several problems in modeling land use change and implementing results:

Consistency—Different categories have been used over time by land use classifiers.

Misregistration—Often the biggest problem is getting spatial resolution consistent between maps over time. Doing this incorrectly creates false change and big discrepancies.

Scale—When there are differences in scale, one cannot compare maps because they have different levels of generalization. GIS allows comparisons between maps of different scales and creates fuzzy data.

Time Series—Reasonably good map data exists only for the latter half of the 20th Century.

Scaling Up and Down—We would like to say that land use change processes on the local level are the same as those on the national level, but this clearly is not the case because land use priorities differ.

Accuracy—All maps are inaccurate. The accuracy depends on how much effort and cost you are willing to put into them.

Calibration—We would like to capture changes as they take place in the real world. But, for many models, they are not compared to the real world.

Performance—Computer models become bigger as more complex things are modeled, and the cost and time of modeling increases greatly.

Von Thunen is claimed as the founder of land use modeling in both economics and geography. He wrote *The Isolated State* for which he took data from agriculture to develop his general model. Von Thunen stated that transportation costs are linear. There is a central marketplace where all agricultural products are taken. Land use change occurs because of the degree of productivity of different land uses and the different costs of transportation. The land use is selected appropriate to the land rent.

Alonso and Muth extended their model to land use in cities and stated that land will be used to maximize the profit of the person using the land, the so called "highest and best use."

Computer-based modeling began in the 1960s when massive computer models were built. These came to a halt with an article by Lee that criticized the models and stated that they were specific to a given location, were non-portable and data-hungry.

Today we have much better data at all levels (local, state and national). We have better time series data and better computers that can solve problems analytically and faster.

There are many types of models, including economic models, GIS-based, cellular automata, SLEUTH, agent-based, and integrated models. We can use modeling to create a dialog between people to determine which kind of land use change we want.

There is an extensive set of information about SLEUTH available on the web at *http://www.ncgia.ucsb.edu/projects/gig*

The EPA and Forest Service land use modeling review reports can be found on the UCIME web site at *http://www.geog.ucsb.edu/~kclarke/ucime*

Additional points from discussion:

- The wild card in the models is roads. Land use change is related to transportation, and transportation modeling is moving toward agent-based modeling.
- Smart Growth advocates mixed land uses. Land use has had a vertical structure, particularly in cities. We do not have a good handle on this as far as modeling is concerned.
- Agreeing on an appropriate minimum mapping unit depends on costs.

Challenges of Applying the Models

Mark A. Wyckoff
President
Planning and Zoning Center, Inc.

This topic, the challenges of applying the models, is presented from the perspective of a community planner with over 25 years of experience for an audience of model developers and users alike.

A model can be defined in many different ways. It can be defined as a physical structure. To boys ages eight to fourteen this can mean a plastic or wood replica of a spaceship, plane, or naval vessel. Among anatomists, dentists, or eye doctors it can be a cut-away view of a body part used to educate, inform and better understand bodily functions. Among architects, it is a 3D building constructed at a fraction of the scale of the final design to help a client understand what his money will buy, and importantly, what it will look like relative to other buildings and landscaping nearby.

The model can be defined as a representation of how something works. Among game makers, it is a simulation of a decision-making structure. Among economists or demographers, a model is one of many multivariate econometric or demographic methodologies that characterize a present or future population. Among land use planners, it is the ability to project and represent a future state or condition such as an alternative land use arrangement, or a build-out scenario in terms of numbers of people, dwelling units, square feet of nonresidential property, agricultural or forest land converted, schools needed, roads to be extended, as well as what it would look like, how it would function and how it would fare through the public decision-making process.

There are some lessons to be learned as model users. Models have influenced us more than we realize. It is difficult to encapsulate how models affect our daily lives. The real promise of modeling is the ability to better predict an outcome. *The Power of Rational Thinking*, while it is inherently powerful, has a considerable weakness when it comes to understanding certain systems that have irrational elements, such as political systems. What we do not know about models can hurt us and we should be more aware of models and their impacts and influences in order to take advantage of the best that models have to offer us.

There are some major challenges in applying models. These include:

- Finding the right model to fit the need
- Having enough knowledge, context or background to evaluate the model's capabilities and "fit" to the situation
- Having enough knowledge to adapt a model that is slightly off the desired applicability to still provide useful information
- Getting the model to "work" when you encounter an unanticipated problem
- Having technical assistance when it is needed
- Being able to explain the model and model results in simple enough terms to satisfy all audiences
- Being able to convince the powers that be to buy a model; and/or to buy into use of the model results in future decision-making
- Being confident that the results will present a reasonable or acceptable range of risk to decision-makers

It can be instructive to examine models from the perspectives of model users, model developers, and community planners. Each perspective can inform model users and increase our ability to face the real challenges of applying models. This also emphasizes the need to have collaboration among model users and developers throughout the model development and refinement processes.

Model users want to understand something better and then use the information to predict how that something will work or what the effects will be in the future. Models hold enormous potential to improve personal and community decision-making. The impacts of alternative policy changes can be predicted before decisions are made. Models allow analyses of how changes in inputs affect outcomes through sensitivity analysis, and sophisticated model users desire the ability to conduct these kinds of analyses with models.

Typical model users are less demanding. They want ease of use, flexibility, and clear results. They want to be able to easily gather information and run a model to get and print results quickly and efficiently. However, these wants may lead to model users who become model abusers. Model abuse by one user undermines the integrity of model use by others, and this makes well-informed model users essential.

Model developers have differing goals. Some may want to save the world and have their models used everywhere, while some may be stimulated by a single or narrowly defined set of problems and not be concerned much for the model users. Sometimes the model maker developed the model for his or her own use and user wants are left unsatisfied. There are also many models developed in academic institutions that have considerable power but may have little adaptability and less documentation for everyday use. There is also a large gap between practitioners and academics, and there is a need for more collaboration between the two groups in order to get better models.

Practicing planners want models that address practical considerations and produce outputs that fit common decision structures. Planners want models that can incorporate common impact assessment methodologies as well as existing and alternative policy structures, and that integrate with procedures for development review and approval involving many separate local zoning bodies. They want to be able to depict visual features of existing and potential development at various geographic scales. As models become increasingly complex, there are many needs of planners such as technical assistance, knowledge of model capabilities, limitations, assumptions, decision elements, and algorithms, clear descriptions of model methodology, model flexibility, etc. These needs can only be met by having expert interface between model users and the community.

Complex models require a sophisticated, or at least well-informed user between the software and the ultimate client (such as elected officials, planning commissioners, or citizens). These intermediaries can serve the role of translator between the model and the citizen audience as well as between the model users and the model developers. Continuing dialogue between the model developers and users, and then continued model refinement is one of the best ways for models to fulfill both the hope and the promise they present for a better tomorrow.

It is important for model developers to keep the basic model methodology clearly in the open, to eliminate "black boxes," and to design flexibility into models. Where experts are needed at the interface, this needs to be open and clear with a common set of ethics to guide the provision of triage, facilitation and translation services.

There should be a common set of ethics and disclosures among experts and model users, as well as a common way to set boundaries on results. It is important to continue training and educating students and model users in common model methodology, model limitations, and how to critique models. The preceding checklist is a starting point.

Additional points from discussion:

Other lessons we can learn as thoughtful model users:

- Not to worship at altar of Holy Model
- Institutional memory of the model (documentation counts)
- Users should insist on calibration data in the documentation
- Keep model in the context of the problem
- Reconcile goals with approaches
- Documentation on how to update projections in the future
- User-build model with the person/group to get their "buy-in"
- Don't use messy data as if it were clean

LESA and County Planning in Fairfield County, Ohio – GIS-Based LESA Model and Growth Management Strategies

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The Land Evaluation Site Assessment model (LESA) provides local governments with the ability to designate the most suitable lands for agricultural preservation. The LESA model consists of two components. The first is Land Evaluation, in which soils are rated and placed into groups ranging from best to worst based on soil characteristics, capabilities, and productivity. The second component is Site Assessment, which identifies factors of importance other than soils that contribute to farmland loss.

This model was recommended as a method of protecting farmland from sprawl based upon the findings of pilot projects initiated in twelve counties in six states. The model is characterized by a consistent application of data and a high degree of flexibility. It maintains the integrity of existing national classification programs and provides a rational planning tool for consistent land use decision-making. This model allows for the inclusion of local values and objectives by using local work groups in the model development. It can be implemented and administered at the local level where it will be used.

Applications of the LESA system can include:

- The identification and ranking of lands for potential TDR/PDR programs
- The identification and prioritization of farms for incorporation in agricultural land protection programs
- The definition of a minimum parcel size in agricultural districts
- The evaluation of impacts of proposed infrastructure projects on agriculture
- The development of guidelines under which agricultural land conversion to nonagricultural uses should be permitted.

The *Development Strategy and Land Use Plan for Fairfield County, Ohio* utilizes outputs from the LESA model as the basis of the land use plan. Fairfield County is one of Ohio's top ten growth counties (1970-2000) with 77% of developed land designated as prime or unique farmland.

When the LESA model is run, it evaluates soils, searches for and identifies land uses, and evaluates land use compatibility. The final output gives LESA scores for farmland, using color codes to indicate score levels on a GIS-based map.

The objectives of the Fairfield County land use plan were to evaluate growth opportunities based on LESA results and to determine where growth should occur. Through a series of workshops, over 200 policies were developed and presented to citizens at public forums for prioritization. Three strategic themes emerged from this process: *Manage Growth*, *Foster Stewardship*, and *Invest Wisely*.

Under the *Manage Growth* theme, the goals of the land use plan are to direct new development toward urban service areas to prevent sprawl, to support commerce and industry, and to promote redevelopment. This strategy addresses land uses, economic development, housing, agricultural preservation, and transportation. The goals under the *Foster Stewardship* theme are to preserve agricultural areas, respect rural character, provide for open space and recreation, and to retain scenic and natural areas. This component of the strategy deals with open space, parks and recreation, environmental issues, and historic and archaeological features. *Invest Wisely* is a strategy that aims to reduce government costs, encourage intergovernmental collaboration, promote public and private investment, promote capital investment planning, and explore innovative programs. This strategic theme involves elements of administrative and budgetary issues, community facilities, delivery of utility services, and transportation.

A variety of plans were developed under each strategic theme, and an *Implementation Matrix* was designed for all policy options. The information in the matrix includes the policy name, the time frame, method of accomplishing the goal, necessary tasks, responsible parties and their method of reporting to the regional planning office. Thus far, the plans and policies have been adopted and the *Implementation Matrix* has been completed. The next steps are to transmit the applicable plans to local political jurisdiction for their consideration, to annually monitor compliance, and to make appropriate adjustments as necessary. The process overall has been a successful exercise.

Additional points from discussion:

- A 50-acre threshold for farming was recommended because it was felt that it would be supported politically. This will differ by township, and the level chosen needs to be supported by the county prosecutor.
- The members of the task force were appointed by county commissioners and represented a broad spectrum of citizenry. The group included technical resource experts; special interest group representatives; business, real estate and development representation; and municipal, township, and county politicians.
- The citizens who participated in the workshops were very interested in “what-if” scenarios and were able to visualize planning scenarios utilizing the computer program.
- Realtors and bankers took part in the meetings and were helpful, but some were opportunistic as well.

CommunityViz: Modeling Resource Management Options in the Arapaho-Roosevelt National Forest

Brenda Faber
Fore Site Consulting, Inc.

CommunityViz™ was used to demonstrate an analysis of the resource management options in the Arapaho-Roosevelt National Forest. The model addressed a host of issues including fire risk abatement, disease treatment, re-vegetation of targeted species, maintenance of wildlife habitat, and management of project budgets. Management strategies developed to form alternative treatment scenarios include clearcutting, prescribed burns, clearcutting with prescribed burns, commercial thinning, and pre-commercial thinning.

Indicators were selected to guide comparisons of the management alternatives. These include perimeter openings, canopy closure, increase in Aspen population, reduction of mistletoe infestation, maintenance of big game habitat, and project costs and revenues.

The project faced several constraints. Burning is not permitted within 400 meters of a riparian area. Clearcuts are not permitted in areas with slope greater than 35%, and openings greater than 40 acres require the approval of a Regional Forester.

CommunityViz is a Planning Support System (PSS) that extends the capabilities of traditional GIS systems to include impact, simulation, and visualization options. It can be used to explore implications of land use alternatives and communicate the results through analytical, predictive, or visual perspectives. *CommunityViz* provides a framework for the evaluation of land use proposals and policy options that can be customized to individual cases using an integrated suite of tools.

CommunityViz consists of a series of three modules built on ESRI's ArcView GIS. Three unique planning perspectives are integrated into one multi-dimensional environment with this software. The first module, the Scenario Constructor, provides the analytical dimension of modeling. It can perform impact analysis and indicator monitoring. This module allows interactive sketching of scenarios, impact analysis, indicator tracking, and alternative comparisons. The Policy Simulator provides the regional forecasting and simulation components of the modeling process. This module allows forecasting of demographic, economic, and land use changes as well as examination of the implications of policy options. The final module is the Site Builder 3D, which performs visual exploration of proposed landscapes. Realistic scenes are created and alternative land use scenarios can be explored in a 3D visual landscape.

All three modules within the *CommunityViz* suite can be used independently in the exploration of land use alternatives. However, the real power of the software comes from the ability to integrate the three unique planning perspectives into one multi-dimensional environment. This software is currently being used in over 75 communities in the U.S. Applications include zoning build-out analysis, site plan review, comprehensive plan update, urban redevelopment, residential infill, agricultural services analysis and land preservation, open space planning, economic impact analysis, and forest vegetation treatment planning.

Additional points from discussion:

- The model was developed by a non-profit foundation, and it has been put on the market.
- Formulas need to be defined by each user. Users need to write them to reflect changes from proposed land uses, but they might not accurately reflect what will happen over time.
- The model allows you to dabble in visualization or forecasts (based on agent-based modeling) but has limitations because people have emotional reactions to agent-based modeling.
- As the user base grows, templates can be developed.
- A model can be developed in an hour if you know ArcView and have a reasonable data set.
- Integration over multiple scales is not yet well represented in the model.
- Land assessment can be done with this model.

Modeling Land Use Change and Impacts in Verona, Wisconsin

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Land use change in the city and town of Verona in Dane County, Wisconsin is modeled in this project. The model uses a combination of tax assessment codes to determine land uses and indices that have been developed to map trends in land use from 1970 to 1997. Images of land uses have been used for interpretation, but the project has relied more heavily on the tax assessment codes and parcel information to assess land uses.

Workshops have been held with local citizens and experts with the goal of developing a land use plan that could feasibly be adopted. The Design Dane action plan resulted from one such workshop and identified three basic land use issues: environmental protection, farmland preservation, and growth management. The action plan incorporated citizens' ideas with those of executives. The goal of the project was to create a citizen-based, technology-linked land use decision-making approach in order to evaluate the impacts of proposed development, visualize alternative development patterns, and to facilitate citizen-based land use planning.

There is no one model or tool that solves the planning challenge, therefore a combination of tools have been used to model land use allocations.

ModelBuilder is a dynamic tool that runs with ArcView's Spatial Analyst Extension. It is used for modeling environmental corridors, which are areas that contain a high percentage of natural features that are desirable to protect. The model conducts analysis through a modeled flow chart and uses arithmetic and weighted overlays.

The community within the study area expressed a desire to have an open space plan with environmental corridors. Vector data was used for environmental corridor mapping and a combination of soil and scoring data was used to perform farmland priority zone analysis. The best sites were chosen on the basis of which parcels contained the highest percentage of farmland priority zones.

A second model, PlaceIt, is a program that is being developed for Verona but will soon be available for use in other areas. It is an extension of ArcView 3.x and allows simple allocation of alternate land uses for comparison and analysis. This software provides tools for assigning future land uses to individual parcels for an entire jurisdiction. Each constructed scenario can be compared with other allocations.

Another tool used is the WhatIf? Planning support system. This model can conduct suitability analysis and project land use demand. It is used to provide feedback to citizen planners on methods of allocating future land uses. The system projects land use based on different growth and suitability scenarios. Preservation and development scenarios were considered, as well as low density and medium to high density growth scenarios. WhatIf? also considers factors such as the supply of and demand for land and public policy scenarios. A Scenario Constructor was also used to look at impacts of land use changes by generating probabilities of where future development will occur based on alternative policy scenarios.

It is important to utilize simple tools that work and that do not require a large amount of time investment. Alternative programs are constantly being developed with the goal of engaging citizens in the decision-making process.

Additional points from discussion:

- There are about 20 tax class systems in Wisconsin.
- Citizen participation using a Smart Board is most effective when using the PlaceIt program and selecting parcels, changing the land use and getting feedback.
- There has been a lot of interest in using 3D visuals of flythroughs.
- The programs that work the best are those that people can use themselves without a lot of training.
- The capacity constraints of water and sewers are not incorporated into the model, but it is acknowledged that they are important.

The Application of Land Use Change Modeling in Michigan: The U.S. 31 Land Use Study

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U.S. Highway 31 starts in southern Michigan and functions as a coastal highway that goes through urban areas. It is a fairly high volume commercial, tourist, and commuting highway. This study focuses on transportation issues on U.S. 31 in the area between Holland and Grand Haven, Michigan. The concerns addressed by the study are congestion, safety, and growth in Ottawa County.

Environmental and land use impacts have been assessed for a period of over a decade by MDOT and have resulted in the creation of several alternative scenarios. The study examines the sprawl impacts of various highway alternatives and was done in collaboration with Michigan State University, as part of the environmental impact statement process.

Given the data constraints, the analysis was based on an integrated set of tools. Economic drivers determine the future of built areas. The model incorporated a modification of Von Thunen’s bid rent theory as a method of analyzing the relationship between economic growth and traffic patterns. Satellite mapping was used to generate land cover maps and to determine areas in which land uses have been changing. Traffic was related to land cover paths. A regression of urban density versus the volume of traffic was estimated. Using demographic parameters generated by the regression analysis, a forecast of transportation patterns was produced. The results compare recent actual transportation and development patterns versus forecasted trends.

The next stage of the project estimates the probabilities with which these outcomes will occur, based on the network of roads and the bid-rent relationship. The model predicts probable land uses and associated accessibility values that are based on length and time in road networks. The accessibility values run through bid-rent relationships to predict where development will occur.

The model results give calculated observed quantities of urban area and predicted urban area under different scenarios in order to demonstrate the trade-offs of different transportation scenarios. Public presentations of the model were made and public web sites have been established to keep citizens informed of the process.

The findings of the study in general indicated that land use change, from undeveloped or open land to developed or built-up area, was primarily caused by the presence of Grand Haven, a major urban economic center located about 30 miles to the east. Any of the north/south U.S. 31 highway alternatives studied showed only minor variations in future development patterns between 2001 and 2020, as compared to the overall growth occurring in the study area, caused by other economic factors. This finding was consistent with the documented growth patterns in the area between 1988 and 2001. Therefore, the findings of the study did not cause the recommended U.S. 31 alternative to be changed. It also helped to explain the dynamics of growth occurring in the study area.

The findings of the Land Use Study will be included in the Final Environmental Impact Statement for the U.S. 31 project. In addition, the findings of the Land Use Study can be used and built upon as a tool for local growth management activities in the Ottawa County area.

Additional points from discussion:

- Values for environmental features change how we look at these models and the aesthetic values associated with them. These inputs and values are not captured in this model, i.e., lake amenities.
- Farmland loss projections, as compared to other sources, are estimated a little lower in this model, but they were fairly close.

Michigan Land Resource Project: A Look at the Future of Land Use in Michigan and the Impacts on its Land-Based Industries

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Michigan's land-based industries – agriculture, forestry, mining, tourism, and recreation – contribute $63 billion to the state's economy. Activities of these industries affect the scenic landscape and influence quality of life within the state. Land use change is a significant issue that can affect these industries in the future. Citizen polls have indicated that people are concerned about land use change, especially the loss of agricultural land and forests.

The goals of the project were established as follows:

- To provide through quantitative distribution a credible estimate of the future land use map for the state of Michigan.
- To evaluate the impact of land use change on Michigan's land-based industries if current trends continue for 2020 and 2040.
- To determine the cumulative impacts of current land use trends for Michigan's economy.

Land uses were classified into the following categories: built (residential, industrial), agriculture, forest, other vegetation (non-forest, non-agriculture), wetland, and water. Digital maps of land uses and landscape features from 1980 and 1995 were used to identify trends, geographic relationships, and demographic and economic projections. Computer simulation models were used to estimate a future land use map of Michigan. Predicted changes in land use, such as the conversion of forests, farms, and other landscapes to sprawl, are predicted for 2020 and 2040.

Land use projection maps were used to evaluate the economic impacts of land use change on agriculture, forestry, mining, and tourism. The loss of land as well as the fragmentation of the landscape are evaluated and related to the economic changes within the targeted industries. The model predicts development patterns as they would continue to occur if no policy changes were implemented.

Overall, there are numerous potential impacts across the land-based industries. It is predicted that conflicts between neighbors and industries will likely increase. As transportation costs continue to rise, so will distances between businesses and support industries, thereby possibly lowering industry profits. The primary asset of land-based industries is the land itself, and as it is fragmented by development, these assets will be priced out of the area. There will be loss of the open space that is provided by land-based industries that adds to quality of life, landscapes, and wildlife habitat.

It is predicted that Michigan will lose 15% of its farmland by 2040, including an approximately 25% loss in metropolitan areas. Michigan is the second most diverse agricultural state in the country, but this diversity will decline in the future. Net forestland will decrease in area by 10% and forestlands will become increasingly fragmented. In the mining sector, building and transportation costs will rise, and ownership patterns and mineral rights will change as land is increasingly fragmented. Accessibility to land for mineral exploitation, development and production will decrease. Built areas along transportation corridors will decrease the aesthetic appeal of recreational and scenic areas. The quality of wildlife habitat, water, recreational trails, and fisheries will decline overall due to land fragmentation.

Many stakeholders were brought to the table through this project to predict the impacts of land use change in Michigan. There are numerous effects of land use change, and the fragmentation of land over time may lead to numerous negative impacts on the performance of land-based industries, which are very important within the state of Michigan.

Concluding Discussion

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Summary of Workshop:

The distinction between land use and land cover matters from a policy perspective. This distinction also matters from a mapping perspective and a long-term planning perspective. Land cover can provide better information about the extent to which land use change is possible or likely. Land use may be ambiguous – urban residential and rural residential areas face different likelihoods for further development and different opportunities for retaining the option value of open space.

The key issues that have been addressed during this workshop include:

- How mapping units are defined
- Measurement errors
- Scale of accuracy and model results

Types of models, within which we have addressed:

- Clarity and results
- Drivers of land use change
- Population change
- Change in job growth
- Institutional and regulatory changes

Land use change models give us the ability to predict an outcome. The cost of modeling, however, is a significant issue.

We have seen case studies that have demonstrated a variety of ways to interpret and model land use changes. Some address the impact of institutional change on future land use patterns. Some address the social, economic, and environmental impacts of land use changes. Others identify where specific land uses make sense. They all emphasize the importance of community and user inputs to the modeling process.

We have recognized that there needs to be a benchmark or starting point for the process. The decision-makers are interested in the potential outcomes – their decisions and policies can make a difference. Different models engage different citizens in different ways. In the political context, if you want to make a difference, it is important to present the model and results in a way that will reach decision-makers.

Visualization is a very powerful tool, as seen from the model and policy results. Individuals know how their small, independent decisions affect them but do not know how these decisions affect the landscape. These models allow us to visualize these effects.

Additional points from discussion:

- There are trade-offs between portability and detail.
- There is a need to connect with educators and to understand how citizens form their values. We need to ask whether they understand the impacts of land use decisions so that they can make decisions based on as much knowledge as possible.
- The models are very complex, and it is important to generate insight into what is happening in the model simulations. A model is what you gain in terms of insight that will hopefully lead to good actions. If there is an important issue but not much data, some models can still be informative even without a lot of data.
- People accept models on faith. The discussion generated here is the most important outcome. We can use the models to generate the discussion. Although models may be sophisticated and data-hungry, it is accepted that results are general. We do not have to have the best data in order to have useful model results. There is utility in taking what you have and making it work.
- We need to take data from the local level and extrapolate to the state level.

Photographs provided by Terri Cory from private collection.

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