Linking Agent Models and Controlled Laboratory Experiments for Managing Community Growth

James J. Opaluch, Peter August, Robert Thompson, Robert Johnston and Virginia Lee[1]
University of Rhode Island
Kingston, Rhode Island 02881

The increasing concentration of human activity has led to significant impacts to the ecological health, quality of life and economic vitality of communities. Indeed, in many cases growth threatens the very amenities that attract people to an area in the first place. The rapid pace of growth is the result of numerous, often small scale land use changes occurring over time. The *cumulative* impact of these diffuse land-use changes can be extremely high when one considers a watershed or landscape scale.

Agent models provide an excellent organizing framework for modeling decisions that determine land use change in the community. The results of computational models provide insights into the underlying structure of systems, and models are often validated by comparing outcomes of simulated systems to actual outcomes. However, empirical validation of agent models faces the considerable challenge of separating the multitude of endogenous interactions among agents from observationally equivalent exogenous landscape and ecological features that influence development decisions. So there are profound limitations to the use of field data as a basis for analysis and validation of agent models.

Experimental methods are a promising avenue for augmenting field data in validating agent models. In the laboratory one can combine a known structure with interactions among actual decision makers brought into the lab. In this sense the experimental environment represents a middle ground between pure computer simulation models and analyses based on field data. Indeed, use of a controlled laboratory environment allows an entire spectrum of analyses, from fully specified computer-generated structure and parameters, to an indirectly observed structure of endogenous interactions among participants, similar to those faced in analyses based on field data. Therefore, augmenting analyses of field data with analyses of data generated under controlled laboratory conditions allows us to better understand the structures underlying decision making processes and the effectiveness of computational tools to identify underlying structures at varying levels of complexity.

This projects links computer simulations of agent behavior with behavior of agents in controlled laboratory experiments. We use CommunityViz® software (WWW.Orton.Org/CommunityViz), to simulate development under different policy scenarios. CommunityViz is an extension to ArcView® GIS (WWW.ESRI.Com), and is made up of three components: Scenario Constructor, Town Builder and Policy Simulator. Scenario Constructor extends the capability of standard GIS software. Town Builder creates 3D renditions that allow interested parties to better visualize growth scenarios. Policy Simulator uses an agent-based model to forecast growth community growth under alternative policy scenarios.

---

[1] The authors are respectively Professor of Environmental and Natural Resource Economics and Director of the Policy Simulation Laboratory; Professor of Natural Resources Science and Director of the Rhode Island Coastal Institute; Assistant Professor of Community Planning; Research Assistant Professor of Environmental and Natural Resource Economics, Associate Manager of the Rhode Island Coastal Resources Center. The research is funded by the University of Rhode Island Sea Grant Program and the Rhode Island Agricultural Experiment Station.

We propose to augment and calibrate agent models using a controlled laboratory environment using the new Policy Simulation Laboratory (SimLab) developed by the Department of Environmental and Natural Resource Economics at the University of Rhode Island (www.uri.edu/cels/enre/preview/SimLab). The SimLab is a world class facility for research that integrates science and decision making. It is comprised of computer systems and audio-visual equipment housed in a group of electronically networked rooms. The facility includes a Policy Simulation room, a Presentation Hall, two Group Decision rooms and a Geographic Information System (GIS) laboratory. The core of the facility is the Policy Simulation room, which contains a network of 26 computer workstations and advanced audio-visual capabilities used to create simulated decision environments. The Presentation Hall is a 125-seat auditorium with in-seat voting capabilities and advanced audio-visual aids. The two Group Decision rooms are conference rooms where participants make decisions while interacting face-to-face, and with notebook computers that are networked with the other facilities. The existing University of Rhode Island Environmental Data Center (EDC), an advanced GIS laboratory, is also networked into the system with a gigabit Ethernet connection.

What makes this facility unique is the close interconnection of the system components, which together comprise an integrated decision research tool. For instance, the group decision rooms might each house a team of policymakers designing proposals for community development. The SimLab and GIS computer systems translate the development plans into resultant impacts to the natural and human environment, and create GIS maps indicating consequences of each proposal for water quality and for fragmentation of natural ecosystems. Simultaneously, audio-visual systems are used to present these management plans and their consequences to "voters" in the Presentation Hall, who then vote on the proposals. Policy makers in the group decision rooms could then obtain real time feedback regarding fiscal, social and environmental implications, as well as voting results, and revise their plans in response.

In the SimLab, real people play the roles of agents by being placed in simulated decision environments, with actual rewards and penalties assessed just as they are in real decision environments. This simulated decision environment represents a middle ground between studies of decision makers in uncontrolled field conditions, and computer simulations that provide complete control over system structure and response. As such, it will provide insights into decision processes whose structure is too complex for estimation with field data, while still including *real* decision makers making choices in response to incentives and constraints. The system also allows one to assess the performance of institutions that may not exist in the real world, to observe and/or control factors in ways not possible in field analyses and to test the effectiveness of estimation techniques designed for use with field data.