SWARMFEST 2016: 20th Annual Meeting on Agent Based Modeling & Simulation

July 31 – August 3, 2016

Dudley H. Davis Center, University of Vermont
Burlington, Vermont

www.swarmfest2016.org

Special Thanks to Swarm Development Group (SDG), Institute for Ecological Diplomacy and Security (IEDS) Gund Institute for Ecological Economics, and Vermont EPSCoR

Keynote Speaker:

Donna Rizzo, University of Vermont School of Engineering

"Invited talk on deep learning and ANNs"

Donna Rizzo's research focuses on the development of new computational tools to improve the understanding of human-induced changes on natural systems and the way we make decisions about natural resources. In 1995, she co-founded a small Vermont business to help speed the diffusion of research and new technologies into environmental practice.

Since joining UVM in fall 2002, she has worked on a number of computational approaches to multi-scale environmental problems, including using artificial neural networks to:

1) develop maps of discrete spatially-distributed fields (e.g., log-hydraulic conductivity and soil lithology),
2) predict local disease risk indicators from multi-scale weather, land and crop data,
3) image and analyze the parameter structure of subcutaneous connective tissue in humans,
4) predict the shrink/swell of soils and develop a watershed classification system,
5) using hierarchical artificial neural networks for diagnosing watershed impairment at multiple scales.

Agenda

Time	Location	Activity
Sunday 7/31		
6-8 pm	Sheraton Hotel- Tuckaways Burlington Pub (87 Williston Road, Burlington)	OPENING RECEPTION- Appetizers and Beverages Provided
Monday 8/1		
8:00-8:30	Davis Center UVM (Room 400, Sugar Maple Ballroom)	B'FAST/REGISTRATION
8:30-8:45	Davis Center UVM	Welcome remarks (Ted and Matteo)
8:45-9:15	Davis Center UVM	**Steve Railsback**: Eighteen Years with One Simulation Model: Victories, Regrets, and Lessons Learned
9:15-9:45	Davis Center UVM	**Dave Dixon**: Classifying outcomes with real-time symbolic dynamics
9:45-10:15	Davis Center UVM	**Chris Koliba**: Modeling the Governance of Complex Adaptive Social Systems: Why ABMs?
10:15-10:30	Davis Center UVM	COFFEE/SNACK BREAK
10:30-11:30	Davis Center UVM	**Donna Rizzo**: Invited talk on deep learning and ANNs
11:30-Noon	Davis Center UVM	**Aleksandra Markina-Khusid, Barbara Blaustein, David Allen, Peter Leveille, Betsy Cole**: Effect of Learning on Stakeholder Negotiation Outcomes
Noon-12:30	Davis Center UVM	**Russ Abbott**: Autonomous causality, agents, inversion of control, and unintended consequences
12:30-01:00	Davis Center UVM	LUNCH
01:00-01:30	Davis Center UVM	**Yushiou Tsai**: Calibration and Validation of the Interactive Land Use Transition Agent-based Model by Using Multiple Data Sources
01:30-02:00	Davis Center UVM	**Linyuan Shang**: Climate change, land use/cover change and extreme events impacts on watershed hydrology, and nutrient dynamics – A case study in Missisquoi river watershed
02:00-02:30	Davis Center UVM	**Markus Schatten and Pietro Terna**: From players to agents via the Project Model MMORPG and the SLAPP simulation shell
02:30-03:00	Davis Center UVM	COFFEE/SNACK BREAK
03:00-03:15	Davis Center UVM	**Scott Merrill**: Innovation in ABM calibration: Using experimental gaming data to inform agent rule sets
03:15-03:45	Davis Center UVM	**Asim Zia**: Simulating the effects of alternate control strategies on heterogeneous farmer behaviors and water quality outcomes: an agent based modeling application in Mississquoi watershed of Lake Champlain Basin
03:45-04:15	Davis Center UVM	**Scott Turnbull**: A Method for Defining Drainage Basins and Water Sensors within a Water Quality Modeling ABM

04:15-04:45	Davis Center UVM	**Serge Wiltshire**: The Dairy Farm Transitions Agent Based Model: Analyzing the Impact of Peer-to-Peer Learning on Indicators of Economic and Ecological Sustainability
04:15-5:15	Davis Center UVM	**Steve Scheinert**: Growing Collaborations: Forecasting Changes in Partnership Networks using a Bottom-Up Approach
6:00-9:00	Chris Koliba's Residence (129 Maple St. Waterbury Center)	RECEPTION AND DINNER
Tuesday 8/2		
8:00-8:30	Davis Center UVM (Room 400 Sugar Maple Ballroom)	B'FAST/REGISTRATION
8:30-9:00	Davis Center UVM	**Michael Poulshock**: An Abstract Model Of Historical Processes
9:00-9:30	Davis Center UVM	**Bill Gibson**: Integrating computable general equilibrium and agent-based models
9:30-10:00	Davis Center UVM	**Brian F. Tivnan and Brendan F. Tivnan** : Impacts of Market Liquidity and Heterogeneity in the Investor Decision Cycle on the National Market System
10:00-10:15	Davis Center UVM	COFFEE/SNACK BREAK
10:15-10:45	Davis Center UVM	**Brian Beckage**: Predictability in complex systems
10:45-11:15	Davis Center UVM	**Christine Harvey**: Massive-Scale Agent-Based Modeling Module for Python
11:15-11:45	Davis Center UVM	**D.G. Webster:** Using agent based models to understand relationships between consumer choice and sustainability
11:45-12:15	Davis Center UVM	**Steve Scheinert**: Bridging the Meso and Micro Level Scales of Social Complexity within a Socio-Ecological System: Modeling the Relationship Between Governance Networks and Land Use/Management Decisions in the Northeastern Segment of the Lake Champlain Basin
12:15-12:45	Davis Center UVM	**Ivan Garibay**: GIS Derived Spatial Constraints for Agent-based Modeling of Aedes Aegypti Population Dynamics
12:45-01:15	Davis Center UVM	LUNCH
01:15-01:45	Davis Center UVM	**Alex Lancaster and Matteo Morini**: Agent-based modeling of research hierarchies driving scientific discovery
01:45-02:15	Davis Center UVM	**Greg Madey**: Impact of Accountable Care Organizations on Healthcare Supply Networks: An Agent-Based Approach
02:15-02:45	Davis Center UVM	**Serge Wiltshire**: Using an Agent Based Model to Evaluate the Effect of Producer Specialization on Disease Resilience in a Simulated Livestock Production Chain
02:45-03:15	Davis Center UVM	**Casey Ferris**: Educational Serious Gaming Application of an Agent-Based Malaria Transmission Model
03:15-03:30	Davis Center UVM	COFFEE/SNACK BREAK
3:30- 4:00	Davis Center UVM	**Mirsad Hadzikadic**: Complex Adaptive Systems and Agent-Based Modeling: The State of the Field

04:00-04:30	Davis Center UVM	**Yushiou Tsai**: Farmers' Decisions for Adopting Best Management Practices: An Application of A Spatially Explicit Agent-based Model
04:30-05:00	Davis Center UVM	**Jason Bates**: Agent-based modeling of cell communities as a virtual laboratory for in silico biologic experimentation
05:00-05:30	Davis Center UVM	**Asim Zia**: Institutional Analytics: Agent Based Modeling of Intergovernmental Dynamics and Control
6:30-9:00	SEABA Gallery (404 Pine Street, Burlington)	RECEPTION AND DINNER
Wednesday 8/3		
09:00-Noon	Chittenden Bank Room (Room 413) Davis Center UVM	Swarm Development Group Board Meeting
09:00-Noon	Field Trip	Kayak or Paddle Board at North Beach, Burlington

Eighteen Years with One Simulation Model: Victories, Regrets, and Lessons Learned
Steve Railsback

My colleagues and I have been developing and using the "inSTREAM" individual-based trout population model since 1998. The model has evolved into a family of fish models applied to a variety of purposes, from basic ecological research to applied river management. We encountered a number of challenges that are common to large, long-term modeling programs and, with help from collaborators, developed strategies and techniques for overcoming these challenges. Lessons learned include: (1) Modeling real systems with agent-based models can create new opportunities for theoretical research, and an ABM that captures the essential mechanisms of a real system can be a very productive research tool; (2) An integrated program of both modeling and field/laboratory research can be very productive of empirical science; (3) Maintaining quality software and thorough documentation is critical; (4) "Validation" of detailed ABMs is a tricky issue; and (5) "Pattern-oriented Modeling" is a very helpful strategy for the most important challenge: how to design a model that is as simple as possible while still capturing the right processes and mechanisms of the real system being modeled.

Classifying outcomes with real-time symbolic dynamics
Dave Dixon

In simulation studies, it is common to examine sensitivity to initial conditions by running large ensembles of Monte Carlo simulations. The resulting statistics are only useful, however, if either all simulations follow similar trajectories to comparable outcomes, or when the trajectories and outcomes can be classified ex-post into categories and conditional statistics produced within each category. Even for simulations with the same trajectories and outcomes, Monte Carlo sampling may result in orders of magnitude variation in the time required to complete a single sample simulation. In numerical methods, the typical response is to set a trio of convergence limits: mini- mum absolute change, minimum relative change, and maximum number of iterations. In a complex simulation model, the number of possible limits can be very large, and the logic for which to impose under what circumstance can be as complex as the model itself. When the outcomes are disjoint, for example extinction versus oscillation versus steady state, simply recognizing which dynamic state exists can be challenging. The dual drawbacks to ex post trajectory/outcome classification is that different state variables may be of interest depending on the trajectory/outcome class, and the appropriate terminal condition depends on the outcome class. The author proposes a simple, real-time symbolic dynamics approach to classify distinct trajectories and to respond appropriately to extinction, oscillation, steady state, and chaotic outcomes.
This paper presents large ensemble Monte Carlo simulations of an agent-based model (ABM) of the network of 304 kidney transplant centers in the U.S. The cur- rent problem is to explore the unintended consequences of regulatory changes. The transplant centers are the agents while the availability of organs and waitlists of recipients are exogenous stochastic variables. The relative risk aversion of the agents is calibrated from historical data for 387,021 transplants over more than 60,000 Monte Carlo simulations. The calibrated network is then subjected to random shocks: a) the institution of public access to each center's performance (one-year survival rate), b) the issuance of warnings for one period (six months) of noncompliance, and c) official sanction (shutdown) for noncompliance over multiple periods. The behavioral responses to these shocks by the centers include removing higher-risk recipients from their waitlists, increasing standards for acceptable donor organs, and increased use of practices known to increase one-year survival at the expense of longer-term patient wellbeing. The first two responses effectively reduce the total number of transplants - thereby reducing the number of lives saved - and the last response results in reduced lifetime patient welfare. The principle interest in using symbolic dynamics in this model is to differentiate classes of outcomes over tens of thousands of Monte Carlo simulations. Additionally, trajectories are analyzed for emergent behaviors.

Modeling the Governance of Complex Adaptive Social Systems: Why ABMs?
Chris Koliba

In this talk I will introduce the concept of governance as both a function of a policy system and also as a systems-level construct. In this way we may think of network governance and governance networks as two different, but interrelated concepts. Multi-level, multi-agent models of governance networks will be introduced, with stakeholder agents serving as objects in ABMs. The alignment of network configurations of observed governance networks can be used to build governance ABMs. Challenges and opportunities for doing so are identified. The value of doing so lies in the potential uses of governance informatics in making policy and governance design considerations.

Effect of Learning on Stakeholder Negotiation Outcomes
Aleksandra Markina-Khusid

This work is based on the MITRE Corporation Innovation Program systems engineering research project APACE devoted to the study of stakeholder characterization and dynamics that manifest themselves in negotiations on large, complex projects. A design negotiation game based on a stakeholder salience framework was created by the APACE research team to explore negotiation dynamics between stakeholders with individual attributes and agendas. The stakeholders were characterized by different levels of each of the salience attributes and assigned individual agendas. Experimental data was gathered during games played by groups of anonymized human participants through a web interface. Two types of groups participated in the experiments: summer interns and senior staff. The data was gathered on the resulting designs, number of state design changes during negotiations, and negotiation tactics employed.

Two main scenarios were referred to as Utopia and BigSystem. Utopia was designed to provide a baseline for studying player behavior when each player has the same individual agenda. BigSystem aimed at modeling a stakeholder combination from a real project examined by the principal investigators. Design of the BigSystem scenario was based on extensive interviews with the major stakeholders of the project. The BigSystem scenario featured significant conflicts among various stakeholder agendas. Ten Utopia games were played: 6 by groups of interns and 4 by senior staff. Fifteen BigSystem games were played: 10 by interns and 5 by senior staff. It was found that the negotiation process takes a non-zero number of iterations even under conditions that strongly favor agreement.

It is useful to examine a scenario's solution space in order to understand what compromises are available to the players and what portions of the solution space indicate success or failure of particular individual agendas. Even with a relatively simple scenario the design space can be very combinatorially large, precluding full enumeration. In solution space exploration there is a place for both the sampling of the design space and reasoning about player agendas and the tradeoffs they require. In this work the solution space for the BigSystem scenario was surveyed using several complementary techniques. Figure 1 shows BigSystem's three dimensional solution space with a variety of possible solutions represented by blue dots and Pareto optimal solutions marked with black stars. Results of experimental games played by groups of interns are shown as green circles and those played by groups of senior staff by red circles.

Autonomous causality, agents, inversion of control, and unintended consequences
Russ Abbott

In Woodward/Pearl interventionist causal relationships a change to the cause produces a change in the effect. It may not be so simple if the cause is a symbol or an abstraction. For example, changing a price causes the number of items sold to change, and changing a traffic light causes traffic to stop. How can that happen? No symbol, no abstraction, can act physically.

To transform a symbolic cause to a physical effect requires that something interpret the symbol and respond physically. Contrast this with physical causal relationships. When one billiard ball hits another, momentum is transferred. But when a symbol is the cause of an entity taking some action, the causal mechanism must be built into the entity. Also, unlike a billiard ball, the effected entity must have access to the energy needed to perform the action. Consequently I am calling symbol-based causal relationships (perhaps paradoxically) *autonomous causality-* the entity creates the effect. I'll call entities with autonomous causality *agents*. Autonomous causality turns the tables on Laplacian causality. Instead of causes pushing the world around according to the laws of physics, agents "choose"—by how they are designed—how to react to symbolic causes. Furthermore, one can't trace energy flows from cause to effect. The agent needs access to a separate source of energy, which it redirects.

Yet agents can't respond arbitrarily—or their responses could not be considered causal. Let's stipulate that agents are programmed to respond to symbols in particular ways. But if that were all there were to it, one could imagine agent programs as fixed: causes would retain control.

But programs can be changed—by evolution (in which case the type rather than the instance changes), by a designer, and most significantly by the agent itself. How an agent changes its pro- gram may be a function of its history—and ultimately of the history of the universe. One can't know for sure how or when an agent will reprogram itself and change how it responds. Recently Woodward pointed out that we care about causality because it gives us a means to manipulate and control our world: a cause offers *remote control* of an effect.

Why do we value that power? Because we have goals. Agents can use our goals to invert the direction of manipulation. Employers make themselves into agents that respond with money or other benefits when an employee performs some work. Incentive programs involve agents programmed to respond with rewards for desired deeds. But an agent programmed to invite a symbolic cause may produce unintended consequences. An apocryphal story has it that to reduce the wild snake population a government offered a reward for dead snakes. The country's resourceful citizens established snake farms.

Calibration and Validation of the Interactive Land Use Transition Agent-based Model by Using Multiple Data Sources

Yushiou Tsai

In rural areas where farming competes with urban development and environmental amenities, urban and forest transitions occur simultaneously at different locales with different rates due to the underlying socio-economic shifts. Here we develop an interactive land use transition agent- based model (ILUTABM) in which farmers' land use decisions are made contingent on expansion and location choices of urban businesses and urban residences. The ILUTABM simulates heterogeneity in land use decisions at parcel levels by differentiating decision making processes for agricultural and urban landowners. Landowners' land use decisions are simulated as bounded rational agents that maximize their partial expected utility functions under different underlying socio-economic conditions given the category of a landowner and the spatial characteristics of the landowner's landholdings. The ILUTABM is calibrated and validated by high resolution spatial data sets available for the Missisquoi Watershed in the rural Vermont. These data sets include National Land Cover Database (NLCD), zoning, parcels, property prices, US census, farmers surveys, building/facility characteristics, soil, slope and elevation. The calibration is executed at two levels: parcel and land cell levels. Land use transition types are calibrated at the parcel levels by using data such as NLCD, parcel and building/facility characteristics. Land use suitability is calibrated at land cell level by using NLCD, soil, slope, and elevation. Optimal combination of parameters associated with land use suitability that maximizes the likelihood of similarity between the simulated and observed land use patterns is determined through multiple simulations. The ILUTABM is data-driven and provides an empirical modelling platform that can be expanded to simulate the outcomes of alternative land use policy and planning.

Climate change, land use/cover change and extreme events impacts on watershed hydrology, and nutrient dynamics – A case study in Missisquoi river watershed
Linyuan Shang

Watersheds support manufacturing, food production and drinking water, and also play a significant role in water, carbon and nutrient dynamics. Understanding these dynamics is essential for better watershed management. Climate change, Land use/cover change (LUCC) and extreme events have been identified as important factors influencing watershed hydrological processes. Climate change can affect watershed hydrology directly (i.e. temperature and precipitation pattern change) and indirectly (i.e. plants phenology change). LUCC alters water cycle pathway, further alters watershed nutrient dynamics. Extreme events can cause tremendous water and nutrient loading.

My research will quantitatively study climate change, LUCC and extreme events impacts on watershed hydrological processes using Missisquoi river watershed. First, I will study climate change and LUCC impacts on watershed hydrological processes using Regional Hydro-Ecologic Simulation System (RHESSys). For this study, I designed a three factors (Climate, phenology change, LUCC) model experiment, which will investigate the factors individual and joint impacts on watershed hydrological processes. Second, I will integrate a dissolved phosphorus module from Daily Century Model (DayCent) into RHESSys model and test the dissolved phosphorus module in Missisquoi river watershed. Finally, I will use the revised RHESSys model to simulate extreme events impacts on water and nutrient loading. The study will improve our understanding of watershed hydrological processes in the context of climate change, LUCC and extreme events.

From players to agents via the Project Model MMORPG and the SLAPP simulation shell
Markus Schatten and Pietro Terna

Massively multi-player on-line role playing games (MMORPGs) are a relatively new phenomenon which provide us with an excellent opportunity to study two important aspects of computing: (1) large-scale virtual social interaction of people (players) and (2) the design, development and coordination of large-scale distributed artificial intelligence (AI). Both aspects have a commonality reflected in the methods used to study them. Whilst such social interaction can be described and simulated using agent-based models (ABM—providing a social science perspective), distributed AI is commonly approached through multi-agent systems (MAS—providing a computer science perspective). Agents in such a complex system include players (or their avatars) as well as artificial programs like non-playing characters (NPCs), mobs (monsters and other beings to be fought) and player bots (automated players).

A very important question to ask, in both the social and the computer science perspective is how do agents organize in order to perform their tasks and reach their objectives? Project Model MMORPG (Large-Scale Multi-Agent Modeling of Massively On-Line Role-Playing Games1) is a current effort, which employs a combined empirical and theoretical approach towards finding the answer to this question. Our research is therefore aimed towards enriching the organizational design methods for the development of MMORPG to foster the development of self-organizing and adaptable networks of large-scale multi-agent systems.

With this in mind, our main goals are:

1. to identify and formalize adequate organizational design methods for developing Large-Scale Multi-Agent Systems (LSMAS) in MMORPGs;
2. to couple them with real-life and future scenarios from industry;
3. to provide open and accessible tools, which will allow for design, development, implementation, control, simulation and maintenance of LSMAS in MMORPG.

The ex-post artificial agent reconstruction of the behavior of the player will be mainly based on SLAPP, Swarm-Like Agent Protocol in Python.2 SLAPP comes from Swarm (Minar et al., 1996). The project started within the Santa Fe Institute (first release: 1994) and represents a milestone in agent-based simulation.

Swarm has been highly successful, being its protocol intrinsically the basis of several successive tools. SLAPP is only one of the possible flavors of Swarm. Other flavors are, as examples, Repast, Ascape, NetLogo and StarLogo, JAS. SLAPP is quite similar to Swarm—with significant addenda, such as the original AESOP layer (Agents and Emergencies for Simulating Organizations in Python)—and it is implemented in Python. In this way, we can use both the simplicity of that language and its advanced internal structure. SLAPP also suggests—as an additional scheduling tool—the recipe metaphor, to organize the events as collections of small acts and steps. A recipe, i.e. a set of directions with a list of ingredients for making or preparing something, in the SLAPP formalism is a sequence of numerical or alphanumerical codes, reported in vectors, and move from an agent to another determining the events and generating the edges of an emerging network.

We code the recipes as strings of numbers—their components. Each number (or, if we want, each label) is related to an act or to a routine of the modeled action. Since recipes represent simple processes, we will explore also the process algebra formalism, i.e. a mathematical framework in which system behavior is expressed in the form of algebraic terms, to further formalize the approach.

Our objective is to use data collected from player sessions, which includes communication and interaction behavior as well as social network data, to construct agent-based models of player behavior with a special accent on organizational behavior. We envision to use such models to later implement artificial agents that make use of such patterns of interaction and hypothesize that they will achieve better results than agents without such abilities.

Minar, N., Burkhart, R., Langton, C. and Askenazi, M. (1996). The Swarm Simulation System: A Toolkit for Building Multi-Agent Simulations. In «SFI Working Paper», vol. 06(42). URL http://www.santafe.edu/media/workingpapers/96-06-042.pdf

Innovation in ABM calibration: Using experimental gaming data to inform agent rule sets
Scott Merrill

Parameterization of behavioral components of human agents in agent based modeling is challenged because data inputs are likely biased. Surveys and interviews querying individuals about their situational behavior may not accurately represent how those individuals would behave if actually placed in the situation context. Augmenting data using other data sources reduces data stream bias, and thus should reduce the distance between modeled behavior and situationally observed behavior. An under-utilized data stream used to capture human behavioral signals is experimental gaming. Here we show how an experimental game was developed to increase understanding of human behavior in the swine production industry. Cluster analysis of our gaming data suggest that behavioral rules can be developed and rules are situational, which allows for added complexity in ABM parameterization. Moreover, evidence suggests that behavioral clusters differ by sampling methodology (surveys to experimental games) provoking the need to examine data stream bias in model development. Preliminary experimental game results were used to inform agent rule sets in a swine health and production agent based model.

Simulating the effects of alternate control strategies on heterogeneous farmer behaviors and water quality outcomes: an agent based modeling application in Mississquoi watershed of Lake Champlain Basin
Asim Zia

In this paper, we test the effectiveness of alternate pollution control strategies with economic incentives that vary across sensor locations and frequency of sensing at watershed scale. We test the hypothesis: A mixed policy mechanism that combines placement of sensors with optimized economic incentives is more effective in pollution control than a single policy instrument (i.e. placement of sensors only or manipulation of economic incentives only policy). An Agent Based Model (ABM) is designed to inform the control theory of decentralized complex systems with applications to control of non-point source pollution as well as multi-criteria optimization of the trade-off between economic development and environmental/water quality conservation. Experimental simulations with alternate control/policy instruments and monitoring regimes are generated to test specific hypotheses pertaining to the control of decentralized complex systems that display behavioral inertia, short-sightedness, rent-seeking, and other challenges typically ascribed to the global control of complex systems that are composed of heterogeneously interacting smaller sub-systems that display local control and self-organization. In the ABM, there are 7858 farmland parcels (queried from three spatial datasets: Vermont parcels, emergency building sites 2004, conservation parcels 2002) in Franklin county) that we use to initialize the "environment" of the model. Consistent with 2002 USDA Ag Census, we assume there are a total of 770 "farmers" that occupy 7858 farmland parcels. Farm size assignment for each farmer is done through a USDA ag census reported "probability distribution function" [pdf] of small, medium and large scale farms with their respective area means and variances. In this version of the model, we strictly assume that each farm, composed of a constellation of farmland parcels generated according to the input pdf of farm sizes, is managed by a "farmer" agent. Each farmer is assumed to have total control of her/his land. In the ABM, each farmer agent makes an investment decision for next year to choose the extent of dairy and cropping mix, as well as chooses their respective technologies, inputs, etc., which, according to predefined economic production functions, lead to primary agricultural products (dairy, hay, corn etc.). Using "farmer investment game" data, in particular hierarchical clustering analysis, we assign farmers to one of four agent profiles: hyper-rational, rational, altruistic, hyper-altruistic. Preliminary results from the ABM vis-a-vis alternate control strategies and policy mixes will be shared in the presentation.

A Method for Defining Drainage Basins and Water Sensors within a Water Quality Modeling ABM
Scott Turnbull

A presentation of a method for instantiating multiple interconnected drainage sub-basins, and their associated water sensors, within the NEWRNet Agriculture Production Agent Based Model. The AgProd ABM explores the impacts of human decisions upon water quality while bridging the gap between social gaming investigations and the real world monitoring of water within a mixed land use watershed. Emphasis will be on the creation of an efficient, object based, modeling infrastructure that captures the spatial and network relationships between land parcel owners, the drainage basins they reside in, and the behavioral effects of the presence of water sensors distributed within the watershed. The AgProd ABM operates under the auspices of the AnyLogic Event Simulator, but the specific implementation of the drainage and sensing subsystem is rooted in traditional Java coding constructs. A presentation of a method for instantiating multiple interconnected drainage sub-basins, and their associated water sensors, within the NEWRNet Agriculture Production Agent Based Model. The AgProd ABM explores the impacts of human decisions upon water quality while bridging the gap between social gaming investigations and the real world monitoring of water within a mixed land use watershed. Emphasis will be on the creation of an efficient, object based, modeling infrastructure that captures the spatial and network relationships between land parcel owners, the drainage basins they reside in, and the behavioral effects of the presence of water sensors distributed within the watershed. The AgProd ABM operates under the auspices of the AnyLogic Event Simulator, but the specific implementation of the drainage and sensing subsystem is rooted in traditional Java coding constructs.

The Dairy Farm Transitions Agent Based Model: Analyzing the Impact of Peer-to-Peer Learning on Indicators of Economic and Ecological Sustainability
Serge Wiltshire

Recognizing the need to simultaneously address both dairy farm viability and the negative environmental externalities arising from certain elements of dairy production, the Dairy Farm Transitions Agent Based Model (DFTABM) was developed. The model was calibrated using primarily USDA Census of Agriculture data, and predicts factors such as farm profitability, attrition, and soil loss under varying assumptions concerning farmer peer network connectivity and the frequency of peer-to-peer learning. Nine treatments were assessed, which differed according to farmer connectivity, frequency of peer-to-peer learning, and the inclusion of a soil loss reduction tax credit. Overall, it was found that high rates of emulation coupled with high rates of connectivity, especially targeted connectivity among smaller farms, yielded the best balance of farm viability and reduction in soil loss. The addition of a tax credit for reduction in soil loss had no clear correlation with reductions in soil loss figures generated by the model. Policy implications from this study include the finding that direct payment schemes for reduction in environmental harm may not always be a viable solution, and that programs to enhance peer-to-peer learning opportunities, especially among proprietors of smaller farms, may present an effective and relatively affordable means by which to effect long-term change.

Growing Collaborations: Forecasting Changes in Partnership Networks using a Bottom-Up Approach
Steve Scheinert

Both social and organizational networks change over time. Current research has examined and documented the change in social networks using dynamic network analysis. However, that research has not yet examined any mechanisms of change, leaving the mechanisms as a proverbial "black box." We show how exponential random graph models can be used to measure the influence of mechanisms for network development, derived from network theory and applied to a goal-directed organizational partnership network, the Vermont Farm to Plate Network. Our method moves beyond recreating network-level statistics to agent based analysis, using an agent based model to induce a bottom-up network change, which allows us to offers some explanation of the underlying mechanisms for network change. Implications for forecasting network growth in a governance and policy context are discussed.
Rather than reproducing network-scale measurements, a bottom-up approach allows the network to emerge from the decisions made by each agent in the network. Exponential random graph modeling measures the influence that certain decision rules for partner selection, such as homophily, heterophily, transitivity, and preferential attachment, had during network formation. Measuring those influences, and then re-operationalizing them in an agent based model, allows us to reconstruct a network from the bottom up. Calibrating such a model to empirical network data then provides a basis for forecasting the growth and development of new network partnerships. We demonstrate such a model and show it can provide better forecasts than randomly assigning new network links. Finally we show how such a model can be calibrated. Implications of building a model that produces accurate forecasts of network growth and development include providing a basis for future-looking agent based models that forecast the impacts of policy interventions in policy systems that are characterized by complex governance networks.

An Abstract Model Of Historical Processes
Michael Poulshock

Background: This early-stage research explores an abstract model of power struggles. Power struggles are ubiquitious in history and the social world, and the objective here is to devise a simple agent-based model that sheds light on the phenomenon in its most essential form.

Method: I n the model, agents have an attribute called *power* that they can use to either benefit or harm other agents. Harming other agents has more of an impact than benefitting them. Agents must decide how to allocate their power among the other agents, thereby forming networks of allies and enemies. Agents are trying to maximize a utility function that incentivizes both relative and absolute power; they want to amass as much power as they can but they also want to deny power to others. The game proceeds in discrete time steps, and each player's moves depend on the potential moves of all other players, making this a game theory problem. A game tree is generated using Monte Carlo methods, representing a sliver of the entire move space, which has high dimensionality. Of the randomly generated game tree paths, agents use intertemporal discounting to evaluate the preferability of their various options, and then they use probabilistic hueristics to pare down these multiple equilibria. This process is iterated to generate an ongoing simulation. Ideally, using this technique, one would be able to initialize a social graph, press "play," and then see how that particular situation is likely to evolve in time.

Research status: The model is still under development as well as computation-intensive, and only small-scale simulations have thus far been possible. Accordingly, there are no comprehensive, conclusive results yet to report. I am hoping to use SwarmFest as a venue for getting feedback on the model as it currently stands, engaging experts from a variety of disciplines, and identifying other researchers with similar interests.

Integrating computable general equilibrium and agent-based models

Bill Gibson

This paper attempts to integrate computable general equilibrium (CGE) models with the multi-agent or agent-based model (ABM) approach. Economic models that employ the CGE methodology begin with a social ac- counting matrix (SAM) to which the model is calibrated. Dynamic paths are then generated and model parameters are adjusted so that the model tracks historical data. Since these are simulation rather than traditional statistical models, validation remains problematic and interval estimates are rarely provided. Microfoundations, moreover, are not always clear and con-vincing. CGE models emphasize structure rather than agency and have been criticized for imposing too much structure rather than letting the data speak for itself. ABMs, on the other hand, minimize structure and are built from the ground up; these models evolve over time and often generate emergent properties that may or may not be consistent with observed regularities in the macroeconomy. This paper develops a prototype model that blends the two approaches, allowing for interaction between the macro-level policy tar- gets and underlying micro behavior of agents with bounded rationality and limited ability to solve dynamic optimization problems in the time available. Much of the paper is devoted to showing how the process of integrating the two approaches might proceed. Interval estimates for macroeconomic indicators are generated based on the probability distributions assumed to guide the behavior of the autonomous agents in the ABM.

Impacts of Market Liquidity and Heterogeneity in the Investor Decision Cycle on the National Market System

Brian F. Tivnan and Brendan F. Tivnan

Just as the day-to-day movement of prices gives little insight into the potential for the dislocations that emerge during a fire sale, so also the day-to-day liquidity of the market gives little indication for the drying up of liquidity that occurs during those events. Contrary to the tenets of demand theory, supply may not be immediately forthcoming at any price. Indeed, it often seems to be the contrary; the rapid drop in prices as those who face the urgent need to liquidate try to elicit the other side of the trade actually reduces the supply in the market.

The key feature of the market that leads to illiquidity during times of urgent demand is that the frequency with which agents arrive at the market is heterogeneous among market participants. Some agents, such as high frequency and statistical arbitrage traders, are continuously engaged in the market and can take action very quickly. Others, such as longer-term fundamental investors, will not enter the market immediately in reaction to changes they observe in the market because they have a slower decision cycle; their decision cycle might involve consulting with others in their firm, or verifying price

Predictability in complex systems

Brian Beckage

Biological, social and economic systems are shaped by interactions among diverse agents. Agents can represent biological species, behaviors in social systems, and corporations in market places. The introduction of novel agents into existing systems can be disruptive, examples include species invasions in ecological systems, rapid shifts in social norms in human systems, and displacement of corporations in economic systems. We examine the outcome of the introduction of new agents into existing systems using cellular automata. We ascertain the predictability of the resultant system behavior based on the characteristics and dynamics of the introduced agents.

Massive-Scale Agent-Based Modeling Module for Python
Christine Harvey

The Massive-Scale Agent-Based Modeling (MABM) Module for Python was developed to facilitate the creation of extremely large Agent-Based Models. This toolkit, developed for Python 2.7, allows for the development of Agent-Based Models with hundreds of millions of agents on a distributed computing cluster using the Message Passing Interface (MPI) communication technique for parallel computing. Distributed computing facilitates very large scale agent-based models. This tool uses event-driven agent communication to synchronize agents on separate processors. This procedure only synchronizes changes to pertinent information in the model at each time step. This technique requires less information to be broadcast which reduces the run time of the simulation while maintaining consistency in the model. The module is useful for developing large-scale agent-based models with hundreds of millions of agents on a high performance computing cluster.

Using agent based models to understand relationships between consumer choice and sustainability
D.G. Webster

Economists recognize that status and luxury are both important components of consumer utility functions and that issues of relative gains can cause a “rat race” in which consumers work harder in order to purchase more than they would otherwise in order to “keep up with the Jones”. This drives up aggregate consumption, which in turn increases the environmental impact of affluence, population growth, and technology. However, there are other social and psychological factors that may have a similar effect. This paper shows that the degree of impact can be significantly magnified by three major social-psychological factors: satisficing, magical thinking, and norms of frugality. Satisficing occurs when consumers select the first good they find that is satisfactory and fits within their consumption budget. Magical thinking occurs when consumers expect that the purchase of a good will miraculously improve their lives. When this improvement does not materialize, then consumers search for and purchase a new “magical” product. If there are strong social norms against wanton disposal of goods, then these two factors should not increase consumption because consumers would be more likely to select durable goods and would use them up before purchasing new items. However, when norms regarding disposal of goods are lax (people are not frugal), both satisficing and magical thinking can lead to much higher levels of consumption and of waste, both pre- and post-consumption. This in turn increases environmental impacts on many fronts, including use of fossil fuels and other resources as well as levels of pollution from the production and transportation of goods. Our paper describes a simple agent based model of aggregate consumer behavior to demonstrate changes in consumption associated with these three factors.

Bridging the Meso and Micro Level Scales of Social Complexity within a Socio-Ecological System: Modeling the Relationship Between Governance Networks and Land Use/Management Decisions in the Northeastern Segment of the Lake Champlain Basin
Steve Scheinert

It is now widely accepted that complex, polycentric networks of public, private and nonprofit sector actors operating across different jurisdictional scale are often responsible for governing socio-ecological systems. Capturing the multi-scalar dimensions of socio-ecological system governance has been posited as one of the major challenges facing those looking to advance the theoretical and computational conceptualization of these systems.

The eutrophication of surface water ecosystems is one of the most prevalent water quality problems worldwide, and results from the inadequate management of the transport of the nutrients, phosphorus and nitrogen, across a complex socio-ecological landscape. This is particularly the case in the Lake Champlain Basin. The flow of nutrients into Lake Champlain is determined through the accumulation of micro level decisions made by farmers, developers, public works administrators, residents, foresters and others with the authority to make decisions concerning land use and land management in this region. However, eutrophication can also be understood as resulting from a failure of meso-level governance networks to effectively define and enforce standards and incentivize land use practices that promote water quality.

To account for the intimate relationship between these micro and meso scales of socio-ecological systems governance a two tiered agent-based model (ABM) comprised of a governance and a land use/management component was constructed for the northeastern region of the Lake Champlain Basin. The ABM is calibrated using empirical data on the financial, human, informational and political capital resource flows that persist across the watershed governance networks, and historical land use patterns and management practices adopted by land users in the region. In this paper, specific attention is paid to the theoretical frameworks and the institutional network data used to construct the governance portion of the agent-based model. Implications for the further development of governance models of socio-ecological systems are drawn.

GIS Derived Spatial Constraints for Agent-based Modeling of Aedes Aegypti Population Dynamics
Ivan Garibay

The Aedes aegypti mosquito is responsible for the spread of several arboviruses including Dengue, Chikungunya, Yellow Fever and more recently the Zika virus. Accurate modeling of the population dynamics of this disease vector within its habitat allows us to understand conditions necessary for Aedes aegypti populations to thrive. Using agent-based modeling, model developers can provide public health administrators with tools to experiment with environmental conditions, intervention strategies and scenarios, and observe the potential effects on local mosquito populations.

Innovative vector control strategies have emerged in recent years, besides the traditional tech- niques such insecticide sprays and breeding site removal. Some of these methods make use of weaknesses in the reproductive process of Aedes aegypti. Two such methods are the Release of Insects with Dominant Lethal gene (RIDL) and Wolbachia infection (an endosymbiotic bacteria). In the RIDL technique, male mosquitoes carrying a self-limiting gene are released and the resulting offspring of these released males die during emergence into adulthood. Cytoplasmic incompat- ibility resulting from Wolbachia infected males with uninfected wild females also causes all resulting offspring to die. However, if infected females are released, all resulting offspring will survive into adults carrying the Wolbachia infection, allowing for the possibility of sustaining Wolbachia infection within the population and keeping mosquito numbers lowered. In this study we present an agent-based model coupled with spatial resource constraints for both male and female mosquitoes and effects of monthly temperature fluctuation. This model is used to estimate the population of mosquitoes in a neighborhood in the Key West, Florida. Then, as a demonstration of the use of this model, simulations are performed to compare the sustainability of the two vector control strategies. The success of RIDL requires released males to successfully compete with wild males for mates. Wolbachia infection also requires the successful mating of infected males and can additionally benefit from the release of infected females if sustained infection is desired. Therefore, both techniques require a prior understanding of the mass and frequency of male and female mosquitoes to be released in order to cause a significant reduction in population.

However, existing models of Aedes aegypti population dynamics focus on factors effecting the dis- tribution of adult females, with little or no attention towards the dynamics of adult male mosquitoes. Originally, models were based off of derivative equations and dynamic life-tables, where mosquitoes populations were considered in aggregates or cohorts, such as CIMSim or its spatially explicit version Skeeter Buster. However, significant advances in computing power have allowed model- ers to create individual-based or agent-based models (ABMs), where mosquitoes are modeled on a individual scale. In these models each agent acts and reacts to conditions in the environment ac- cording to a set of rules and parameters. These rules and parameters are derived from field studies of the Aedes aegypti and the balance between accuracy and computation time of the model can be controlled through assumptions of the rules and parameters. Additionally, by simply changing the parameters of the model, the modeler can adapt the model to simulate varying environmental conditions or even the behavior of various species of mosquito, making agent-based modeling a highly versatile technique.

We have developed an agent-based model of Aedes aegypti inspired from the literature, coupled with geographical information systems to identify zones with resources vital to the survival of both male and female Aedes aegypti, in addition to modeling possible locations of breeding sites. By using a two class k-means classification algorithm we have identified vegetation zones and urban zones in the neighborhood under consideration, which are rich in nutrition sources for male and female Aedes aegypti, respectively. The identified regions are then overlain with a regular point grid (points spaced 20m apart for the purpose of this study) in order to capture the distribution of resources in the environment. This point grid is then used as the continuous space upon which agents in the ABM exist. Breeding sites are assigned to urban zones at a probability equal to the Aedes aegypti House Index reported by the Florida Keys Mosquito Control District field studies.

The agent-based model of Aedes aegypti extends the computational decision making tree used in [8] to include the nutritional requirement of males. Agents are considered to exist in an aquatic or fetal stage and then emerge into the adult stage. Mortality rate of the fetal stage is temperature dependant and an aggregate of functions of temperature obtained from the literature. Similarly, duration of the fetal stage until emergence, adult life duration and egg count during oviposition are modeled as functions of temperature from the literature. Other parameters such as sensory range, displacement speed and circadian rhythm also use values from field studies and previous models. The model was applied to a neighborhood in the Key West, Florida, over an area of nearly 30000 m^2 with around 50 households. The resulting grid consisted of 93 urban zones to 288 vegetation zones. The temperature was varied monthly and ranged between a low of (19°C and high of 30°C). The spatial distribution of the vegetation zones, urban zones and breeding spots together with the temperature, constrained the population to a mean high of approximately 2000 during the fall and around 600 in late winter.

Finally, the model was used to simulate RIDL and Wolbachia infection techniques aiming to reduce Aedes aegypti populations in the neighborhood considered. Preliminary results demonstrated the ability of Wolbachia infection to be sustained into the following year after releases were stopped. In contrast RIDL required periodic releases and showed no such sustainability.

Agent-based modeling of research hierarchies driving scientific discovery
Alex Lancaster and Matteo Morini

Agent-based modeling (ABM) has been an active tool in complex systems research for at least two decades, and research using ABM tools and methodologies have expanded into fields far beyond their original home in computer science and artificial life. ABM is now widely deployed across fields as disparate as archeology, social science, economics and philosophy. There is a growing crisis in the structure of basic science brought about by both decreases in funding in basic research as well as demographic trends amongst the scientific professional class. This has three main consequences: first, is the growing scarcity of stable academic jobs leading to a loss of talented individuals, second is the the "drying-up" of many pharmaceutical pipelines, third is the long-term threat to innovation. Despite a rhetoric of increasing interdisciplinarity, and the growth of institutes specifically devoted to the same, the current structure of many sciences (particularly in resource intensive areas like biomedical science) continues to favour hyperspecialization, and traffic, even between subdisciplines, let alone external perspectives, remains relatively low. Within universities, there is a growing focus on obtaining grant money for its own sake, leading towards an extremely risk-averse funding climate. Although these trends are widespread across all sciences, they are particularly intensified in biomedical sciences.

Recent provocative results from the field of artificial intelligence and search suggests that in the context of developing breakthrough and ambitious targeted objectives (such as "curing cancer") and attempting to quantitatively measure progress towards them via benchmarks and milestones, may not always lead to the stated goals. A better, but perhaps counterintuitive, strategy in the pursuit of ambitious goals, is to relinquish the mentality of goal setting altogether, in favour of an open-ended search for novelty. In the research context, the setting overly targeted and ambitious objectives can lead to "stovepiping" of ideas and resources under the control of a smaller number of investigators. The success of the open-source development model in software suggests that more nimble and open approaches such as open science, DIYbiology, citizen science, independent scholarship and research consortia and the rise of an startup "indiescience" culture may provide a way forward.

Agent-based and network modeling approaches provide powerful ways of capturing the dynamics of the sociopolitical structures that drive academic science and innovation. In particular, ABM can capture important aspects of the reward and incentive structures for carrying (or not carrying out) particular research programs, and can investigate alternative research models for exploring a larger space of scientific "truths" in a systematic fashion. In this talk we will present an ABM framework for understanding the dynamics in the research enterprise itself. This framework models individual researchers as agents that have individual research interests and goals, but can be arranged into hierarchical as well as peer-to-peer structures.

Impact of Accountable Care Organizations on Healthcare Supply Networks: An Agent-Based Approach
Greg Madey

The evolution of Accountable Care Organizations (ACOs) marks a paradigm shift in the U.S. healthcare landscape. ACOs were created under the Affordable Care Act (also known as *Obamacare*) and first launched at the national level in 2012. Categorized under the broad umbrella term of *managed healthcare*, an ACO attempts to tie provider reimbursements to quality metrics and reductions in the total cost of care. Along with various other network-based managed healthcare organizations (MCOs) such as Health Maintenance Organization (HMO), Preferred Provider Organization (PPO), and Point Of Service (POS), ACOs include economic incentives for physician groups, insurance companies and patients to select less costly forms of care, increased beneficiary cost sharing, programs for reviewing specific services needs, controls on inpatient admissions, lengths of stay and so on.

Traditional analytical approaches do not lend themselves to examine the complex phenomenon of the emergence and growth of the ACO in the healthcare network. Due to the inherent complexity of the U.S. healthcare system, realistically assessing the effects of ACOs is a significant challenge, and its overall impact remains widely debated. We adopt a Complex Adaptive System (CAS) view to examine the growth and impact of ACOs. To model the dynamic interactions and complex properties such as emergence, aggregation, adaptivity, and heterogeneity, most of which are present in the *managed healthcare* scenario, we present an agent-based model (ABM) to examine (i) the growth of ACOs among physician groups, (ii) the decision processes by physician groups within healthcare supply networks, and (iii) the impact of ACOs on physician groups' profit. The ABM allows us to simulate physician groups' entrance and exit of ACO based on a set of simple rules and their complex interactions with other agents.

In the ABM, each *Patient* agent is connected to a *Physician Group* agent and an *Insurance Company* agent. An *Insurance Company* agent can have multiple *Physician Group* agents, each of which can potentially be connected to an *Accountable Care Organization* agent. The ABM is implemented as discrete-event simulations in Java. Time is modeled in yearly time steps, with each simulation running for at least 10 years. The ABM is validated using empirical data, which are collected and reorganized from several databases such as the 2012 HIMSS AnalyticsTM Database and the 2013 HospitalCompare database.

Based on an ACO's cost-saving goals and reward structure, it assumes that by joining an ACO, on average, a physician group will achieve a cost reduction of $20/patient visit, and a member physician office will share a portion (50%) of the cost savings. ACO formation is modeled in a region in the Midwest part of the United States, with a network consisting of a 200,000 patient base, 3 insurance groups and 60 physician offices (5% of which participate in an ACO). A dynamic network graph depicts the evolution of ACO membership for one simulation run. It connects all physician groups to their corresponding insurance companies, and also shows which of the physician groups are currently members of the ACO. As a result of the dynamic interaction between the patients, physician groups, insurance companies, and the ACO, patients switch insurance companies as well as physician groups.

The ABM provides a general framework to investigate the complex social and behavioral relationships inherent in managed healthcare by employing a variety of approaches such as social simulation, modeling, and network analysis. With its predictive power to analyze *what-if* analyses scenarios, it offers a flexible tool to investigate related research questions such as alternative efforts at healthcare cost control, better configurations, incentives, operational principles, and/or guidelines for physician groups and ACOs, and so on.

Using an Agent Based Model to Evaluate the Effect of Producer Specialization on Disease Resilience in a Simulated Livestock Production Chain
Serge Wiltshire

This project endeavors to assess the resilience of the U.S. hog production sector regarding the spread of catastrophic disease outbreaks under production chain network typologies which vary based on the level of producer specialization. Previous work has pointed to the importance of spatial location and the connection patterns within heterogeneous, multi-context contact networks in understanding epidemic spread in complex systems. Following this research, an agent-based model which probabilistically builds a representative sample of the U.S. hog production industry was coded, representing systems of interactions between producers, feed mills, and slaughtering facilities as nodes and ties in an industry network. In consultation with a cohort of livestock epidemiologists, three interaction contexts were identified as significant facilitators of epidemic spread, each carrying a set risk and occurring at a set frequency. Hoofstock were coded as passive objects which could be transferred between agents based on heuristics taking into account hoofstock life cycle, as well as the industry role and physical proximity of the agents. A series of parameter variation experiments assessing the relationship between the spatial density of producers and the propensity for systemic percolation were performed to assess the resilience of systems of low-, medium-, and high-specialization producers. It was found that a network composed only of low-specialization “Farrow to Finish” farms could on average withstand significantly higher spatial density before a systemic outbreak percolated through the system. This result may be explained by the lower overall connection density in these low-specialization networks, as well as the observation that low-specialization typologies cut out one of the interaction contexts entirely. In multi-context network studies, additional interaction contexts often form bridges, linking portions of a network that may not otherwise interact. In the case of an epidemic, the absence of these bridges may isolate the infection, increasing system-wide disease resilience.

Educational Serious Gaming Application of an Agent-Based Malaria Transmission Model
Casey Ferris

Malaria is one of the most important diseases today. It causes an estimated half a million deaths per year, mostly in children under 5. The primary human-based malaria parasite is Plasmodium falciparum. It is responsible for roughly 75% of the malaria cases in Sub-Saharan Africa, as well as almost every malaria-related death. This parasite has a relatively complex life cycle that makes it extremely difficult to defend against using drugs and vaccines. Therefore, the primary defense against malaria is to decrease human contact with the non-human carriers of malaria, mosquitoes. Human-based malaria is only transmitted by females of the genus Anopheles. The species Anopheles gambiae is one of the most efficient vectors in the world. In Sub-Saharan Africa, specifically, Anopheles arabiensis and Anopheles funestus join Anopheles gambiae to make this location particularly prone to high endemicity. All three of these species have differing behaviors, such as when they prefer to feed, where they prefer to feed, and who they prefer to feed on. The tropical climate and primarily outdoor lifestyle of the people living there also contributes to the high rate of malaria transmission.

With an increase in computing power, agent-based models are becoming more widely used for simulating disease transmission environments. Developed by the Institute for Disease Modeling, EMOD is a proprietary epidemiological modeling software package designed to determine the combination of interventions that may eventually lead to disease eradication [3]. As an agent-based model, EMOD directly models the humans, the mosquitoes, and the parasites in the system. In order to run, EMOD requires demographic, weather, mosquito, and parasite parameters as input. EMOD also allows for the definition of almost all available malaria interventions. Usually, EMOD allows for almost everything that could be defined within the model to be defined by the user. This makes it a robust, effective modeling tool that has a useful malaria transmission component. However, with its robustness comes a complexity that makes it difficult for some users to learn quickly. In some cases, the difficulty results in the complete abandonment of the EMOD model as a tool for that user.

Gamification is the creation of a video game that is based on some preexisting scientific application. Serious gaming is when something gamified is used for a non-recreational purpose. Gamification and serious gaming are becoming useful tools for many scientific purposes. In recent years, serious gaming has been used for education [2] and citizen science [4], and has joined together educators, scientists, and video game developers in an effort to increase learning [1]. By creating a lower barrier-to-entry and a recreational feel to scientific investigation, serious gaming allows for a more relaxed environment for learning and experimentation.

Towards this effort, the EMOD model could be gamified as a viable way to lower the barrier- to-entry to learn and use the model. Additionally, a serious game version of EMOD could also be used as a teaching tool to those who may need to know the basics surrounding malaria transmission and the dynamic interactions of the individuals involved. With these objectives in mind, a serious game is being developed using the EMOD model as the base. In this game, players will be able to run the model, testing various options and interventions, attempting to eradicate malaria in an area. The main challenge for the player is the limited amount of money they have available for interventions. Additional challenges include variability in demographics, mosquitoes, and climate.

Complex Adaptive Systems and Agent- Based Modeling: The State of the Field
Mirsad Hadzikadic

Complex Adaptive Systems and Agent-Based Modeling have been around for over 50 years now. One would expect to see much progress in their commercialization, acceptance, teaching, and academic degrees. However, this is not the case. The field is still struggling to demonstrate its utility to businesses, politicians, academic administrators, students, and society at large. Why is that? What are the issues that are holding back this field? Is there hope that these issues will be resolved?

This talk will attempt to define the perceived issues with the fields of complex adaptive systems and agent-based modeling, and to provide some answers to the question of their utility in the today’s world.

Farmers’ Decisions for Adopting Best Management Practices: An Application of A Spatially Explicit Agent-based Model
Yushiou Tsai

Agricultural best management practices (BMPs) have been developed to mitigate non-point source pollution and maintain agricultural productivity. Policy makers have recognized the importance of using incentive programs combined with regulations to increase BMPs adoption rate. This study aims at providing insight into reducing farmers’ perceived adoption barriers through the theory of planned behaviors. In this study, we used structural equation modeling (SEM) to examine farmers’ likelihood of BMPs adoption given their socio-economic and social psychological factors and on-farm land use patterns. We then implemented the SEM concerning BMPs adoption in a land use agent-based model (ABM). In addition to land use modeling, this spatially explicit BMPs adoption ABM simulates individual farmer’s likelihood of adopting three BMPs—riparian buffer, cover crop, and reduced tillage—every year.

A surrogate— intention to adopt— was used to represent the farmers' likelihood of BMPs adoption. We employed the theory of planned behaviors postulating that intention is affected by perceived social norm, perceived behavior control and past practices. We termed these (i.e., intention, perceived social norm, perceived behavior control, past practices) social psychological factors. One of the perceived social norms in our study is whether a farmer's friends influence their intention to adopt. The perceive behavior control represents the farmers' level of confidence and/or knowledge in implementing BMPs. In the SEM, we postulated that the social psychological factors are affected by the farmers' socio-economic factors such as age, education, financial condition, farm size, or conservation easement. The BMPs adoption ABM is data- driven. It provides an empirical modeling platform that can be used to examine the efficacy of different incentive programs on agricultural BMPs adoption.

Agent-based modeling of cell communities as a virtual laboratory for in silico biologic experimentation
Jason Bates

The human body is a dynamic community of biological cells embedded in a substrate that they have collectively secreted over time. Accordingly, the cell can be usefully considered as the primary agent of a biological system. Much of biological investigation tends to focus on what goes on inside cells largely because of the successes of molecular biology and because knowing what genes a cell expresses and what proteins it produces has obvious implications for the development of pharmaceuticals. On the other hand, interactions between different cells and between cell and substrate determine both health and disease, so understanding biology at this level focuses more on the question of what cells do as discrete entities rather than on the details of how they do what they do. Agent-based modeling is naturally suited to addressing questions of this type because the cells of the body are so compellingly representable as agents in agent-based models that operate according to characteristic rule sets. Importantly, this obvious correspondence is readily appreciated by investigators in the life sciences who, while not always being steeped in the disciplines required for complex mathematical modeling, nevertheless harbor the extensive knowledge and deep understanding of biological processes required to inform such models and make them realistic. Agent-based modeling thus allows computational modelers and life scientists to collaborate on sophisticated research very quickly. We have been taking this approach to studying how allergic inflammation in the lung may arise, and in particular how it may resolve, because failure of the latter has particular relevance for the pathogenesis of chronic inflammatory disease. We have used an agent-based model to test the hypothesis that allergic inflammation in the lung normally manifests as a series of self-limited unitary events we call the inflammatory twitch. By using the model as a virtual laboratory for performing *in silico* experimentation, we have examined ways in which the inflammatory twitch might fail to resolve and thus lead to a chronic inflammatory state corresponding to asthma.

Institutional Analytics: Agent Based Modeling of Intergovernmental Dynamics and Control
Asim Zia

Multi-level institutional mechanisms exist at the core of post-industrial societies, which are manifested in variegated forms of intergovernmental arrangements, public-private partnerships, and inter-organizational networks. Both quantitative and qualitative studies of multi-level institutional mechanisms have recently been undertaken to understand the differential impacts of institutional design considerations on serving the public interest and solving complex public policy problems. Oran Young (1999; 2002), for example, proposes that the success of global policy regimes is tied more closely to the match between the institutions and the biophysical and socioeconomic settings in which they operate than to some generic measure of how easy or hard are the problems to solve. Along the similar lines, Ostrom's (2005) Institutional Analysis and Development (IAD) framework aims at understanding the impact of multi-level rule structures – constitutional to legal and operational rules – on the emergence of alternate societal, political, economic and environmental outcomes. In this vein, we explore the notion of "institutional analytics", wherein empirical and computational research is deployed to understand the role of differential multi-level institutional mechanisms in serving public needs.
Differential assemblages of multi-level institutional rules generate a complex landscape of resource

allocation dynamics across public and private sector activities and locations. In this study, we explore apply these institutional design theories to model the intergovernmental decision making processes. We simulate inter-agency rule structures to predict the differential allocation of infrastructure investments across regions and local towns. Within the broader scope of land-use, transportation and economic interactions, we address the question: how intergovernmental institutional rules are manipulated by federal, state and regional government agencies to exert their control over infrastructure resource flows? We explore this question through a computer simulation modeling approach to simulate alternate intergovernmental institutional rule structures and their effects on sustaining a continuity or discontinuity in attracting the increasingly scarce governmental transportation funds for various regions and local towns. We find that relatively small changes in multi-level institutional designs, such as investments in enhancing the technical capacity of local governments, could trigger relatively large effects in shifting the basins of attraction. We also find that the "basins of attraction" are strongly linked with perpetuating one of the many possible alternate stable states and influence the resiliency and fragility of systems under consideration.

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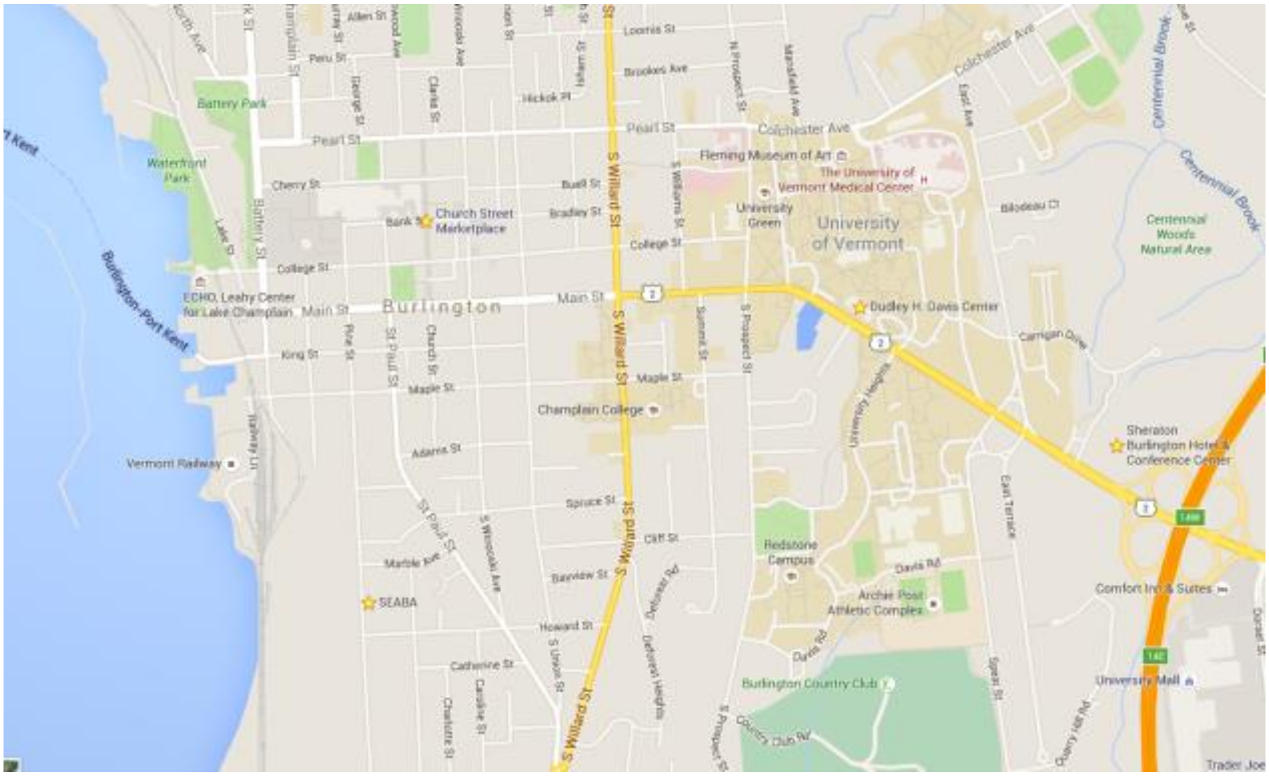

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