Agent-Based Modeling (ABM) 17:

A Symposium That Advances the Science of ABM

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Poster Abstracts &

Position Papers

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Poster Abstracts and Position Papers

Nazia Arbab

Impacts of land use conversion on biodiversity near protected areas in New Jersey

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Key words: land use conversion, agent-based model, species diversity, spatial logistic regression, habitat suitability

The land use change near protected areas affects species diversity in forests in eastern North America. These forests provide suitable environments for rare and endangered species. Due to urban growth, land parcels close to protected areas are undergoing land cover and land use transitions. Land use transitions due to urbanization often alter landscape and cause fragmentation. This result into a modified, reduced and isolated ecological boundaries for several species, which alter the species response in terms of their susceptibility to the new modified landscape.

To assess the impact of human induced land use change behavior on biodiversity, the land use patterns generated from a spatially explicit, land use agent-based model (ABM) is used as an input into a biodiversity model. Analyzing the causes and consequences of land use conversion decisions at the parcel level provides spatially explicit details of land use change driven by factors such as proximity and spatial spillover effects on biodiversity at disaggregate scale. Spatial logistic regression models are built to estimate the spatial externalities (neighboring impacts and proximity factors) influencing land use conversions near protected areas. These empirically based estimates are then implemented into an ABM for land use conversions. Lastly, the results from the ABM is linked with a habitat assessment model to provide key understandings of land use processes and its impact on edge effect and habitat suitability for seventeen avian species in highlands of New Jersey.

Finding Environmental Opportunities for Early Sea Crossings: An Agent-Based Model of Middle to Late Pleistocene Mediterranean Coastal Migration

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Keywords: Pleistocene, Mediterranean Archaeology, coastal migration, spatial analysis, human migration

Sidestepping the expected timing of certain milestones along the evolutionary trajectory of early humans, this work instead seeks to examine where and how past environments could have created opportunities for early sea crossings. Using an agent-based model, it operationalizes a revisionist conceptual model in which the sea was less of a barrier and more of a facilitator for early human migration in the Pleistocene Mediterranean, setting it apart from other, more terrestrial models of Pleistocene migration through the region. It places evidence for earlier than expected human presence on oceanic islands into the context of larger spatial processes. It also allows these processes to be studied apart from strict relationships between proposed causes and effects.

This agent-based model of human migration in the Middle to Late Pleistocene Mediterranean is used to simulate the choices of early humans based on their immediate environments. The spatial analysis and model are presented in an R Notebook format to facilitate greater transparency and reproducibility. Though more informative than strongly predictive, the format of this work and the use of free, open source software to build the model will allow other researchers to adapt this model for their own work.

Mobile data for agent-based modeling

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The growing prevalence of mobile and smartphones across the world is changing the potential for providing empirical support to agent-based models, and in particular, closing the gaps that exist between an individual's true decision and the final, calibrated, modeled decision. I present several examples of detailed, high frequency behavioral data collected during a yearlong pilot study in rural Bangladesh, in which farmers responded to survey tasks on a daily basis via a 'microtasks for micropayments' model. I then discuss their potential application to agent-based models in the context of a model currently in development, the MIDAS (Migration, Intensification, and Diversification as Adaptive Strategies) model.

Patricia Belmont

Thresholds of land-use change in the transformation of an urban wetland in Mexico City

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Key words: ABM models, urbanization, land use, socio-ecological systems, Xochimilco wetland.

The remains of the Xochimilco wetland in the southern urban area of Mexico City is suffering profound modifications in the ecological and social structure due to management and institutional failures, cultural fragmentation, water and soil pollution, changes in land use, disorganized tourism and urbanization, among other reasons. Two persistent elements of this socio-ecological system, water in the canals, and chinampas agriculture systems (ancestral agriculture techniques), seem to be key features in the maintenance of the resources and services associated with it, such as water extraction, climate regulation, biodiversity, food production and its function as a nutrient reservoir. The dynamics between producers (chinamperos) and the ecosystem management need to be understood to determine the decisive elements taken to make changes in the agricultural vocation of the chinampas and favor land abandonment, urbanization or keep the chinampas landscape.

The Agent Based Modeling is a practical and powerful tool to help us find factors that influence decisions, which can modify the socio-ecological system. Models of future scenarios can contribute with system knowledge to develop appropriate strategies including adaptive management and accurate policies to maintain the wellbeing of the ecosystem and Mexico´s City population and therefore to contribute to the increase of the city resilience. Scientists within communities and stakeholders have to co-produce knowledge through methods and tools that facilitate communication and mediation between all kind of actors and disciplines.

Florian Breitwieser

Simulation of spatiotemporal effects on the wood harvest and wood fuel market in an Austrian province: An agent based approach

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Keywords: Agent-based modeling, Market simulation, GIS-Data, Fuel wood market, Forest management

In recent years, the term “sustainability” gained growing attention in the energy supply market. This study reviews the potential of applying agent-based modeling to forest fuel markets and supply chains. More precisely, the paper aims to model and simulate the forest fuels market, focusing the wood chip production for heating purposes, based on sustainable forest growth and yield. The developed model utilizes three types of agents, being either a supplier, acting on the demand side of the supply chain or being a "trader" connecting supply and demand. Suppliers are different forest owner types such as small private owners, large forestry companies and governmental forests. Their forest management decisions are based on the available sustainable yield of their forests. These decisions directly affect the available forest fuels in the supply chain. On the demand side local wood-chip consuming power plants are present. Specific agents - "traders" - are connecting supply and demand, by trying to fulfill the fuel demand of the heating plants. The "traders", present in the model, compete for the available forest fuel supply which is affected by: a) forest growth modeling and b) the forest management operations. The aim is to minimize the transport distances and purchase costs for forest fuel.

The agent-based model utilizes spatial data of forests, forest owners and heating plants. A set of scenarios evaluate the general potential of forest fuels in the region by a province-wide and harmonized central forest fuel management. The second set of scenarios review different mar- ket situations, which are mainly influenced by the forest fuel price and individual management decisions of forest owners - i.e. suppliers. The study elaborates on the agent-based modeling and simulation of the forest fuel supply chain and presents results of several simulation scenarios located in the Austrian province of Carinthia.

Gabriela Bucini

Agent-based modeling of coupled human behavior and disease spread in the regional U.S. swine production system

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Keywords: Agent based modeling, biosecurity, epidemiology, risk attitude, swine production

The US swine production system involves a complex network of production premises, feed mills, auction houses, sales markets, animal fairs, and slaughter plants. Movements of animals and feed deliveries have exposed animals to disease. Biosecurity practices, such as disinfecting livestock transportation vehicles, or constructing shower-in / shower-out facilities, are designed to reduce disease transmission probabilities. Biosecurity adds another layer of complexity to structural epidemiological models because biosecurity adoption and compliance with rules is affected by human decisions. In particular, attitudes regarding risk have been shown to play a key role in the willingness to increase investment in biosecurity. We use Agent Based Modeling to simulate the effects of biosecurity adoption on disease transmission, accounting for variations in agents' risk attitudes. Our agents (production premises, auction houses, feed mills and slaughter plants) are connected via networks of animal and feed transfers, with each transfer mode being associated with infection spread probabilities modulated by network connectivity and the agents' biosecurity levels.

To make our model more realistic and useful for both researchers and stakeholders, we intend to incorporate several features: 1) integrating intelligent agents by making agents capable of learning from past infection events, and allowing for biosecurity adaptation; 2) tuning/validating the model using a variety of data inputs; and 3) including weather geospatial data to account for seasonal variability in virus occurrence and survival. Stakeholder engagement with the ABM is a central feature of the project. Ease-of-use features including the development of ABM dashboard functionality, facilitates ongoing expert input for model parameterization and validation.

Sergey Budaev

Predictive Decision Making in Evolutionary Agents: An Application of Modular Object Oriented Approach

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An organism faces a variety of challenges from its environment during lifespan and has to respond adequately to survive and reproduce, thereby contributing to the subsequent evolutionary history. The evolution occurs when morphological, physiological and behavioral traits have genetic basis and vary across individuals. Many traits, especially behavioral, display high degree of plasticity, and individual variability and diverse alternative strategies are typical. Many such individual differences are repeatable and consistent over time and across contexts. Behavioral plasticity and consistent individual differences are documented in virtually all behavioral domains. In most cases the patterns that are observed indicate that there is seemingly no single “optimal” phenotype as a range of strategies, syndromes and “personalities” are equally adaptive.

There is also a growing understanding that the behavior of many organisms are much more flexible than has been thought previously. Many behaviors are based on predictive decision making mechanisms that are modulated by various stimuli and the internal global organismic state. Even such simple responses as the phototaxis can be environmentally modulated in quite complex ways. The long standing metaphors of a single adaptive “norm” with a “white noise” variability around and “reflexive” responding to specific stimuli should be discouraged as too simplistic.

Many “classical” game theory and optimization models are not very successful in explaining and predicting the dynamics and outcome of behavioral adaptation and evolution beyond a very coarse and general level. The “phenotypic gambit” inherent in simple modelling—when the phenotype is considered unconstrained and only the fitness consequences of behavior are modelled—should be viewed as a gross oversimplification. Indeed, what is really adapted is the whole organism with its integrated genetic, hormonal neurobiological and cognitive architecture rather than isolated “optimal” traits. Whereas optimization models are an ideal starting point for understanding adaptation, novel approaches to the modelling of the evolutionary process, integrating the proximate and ultimate mechanisms, are necessary.

There is, however, a fundamental challenge: the patterns of plasticity and phenotypic constraints can both result from natural selection and affect it. To accommodate such added complexity, new generation of models is starting to focus on the individual organism and implement the basic components of the whole organism's machinery from genes to hormones, physiology, hormonal architecture, to the neurobiology, including perception, appraisal, cognition, and further to the behavior. The complex patterns of evolution can then be simulated realistically using agent-based models implementing genetic algorithms within a virtual computational system.
We will present an overview of large scale simulation model under development that implements a general decision-making architecture in evolutionary agents. Each agent is programmed as a whole

virtual organism including the genome, rudimentary physiology, the hormonal system, a cognitive architecture and behavioral repertoire. They “live” in a stochastic spatially explicit virtual environment with physical gradients, predators and prey. The primary aim of the whole modelling machinery is to understand the evolution of decision making mechanisms, personality, emotion and behavioral plasticity within a realistic ecological framework. An object-oriented approach coupled with a highly modular design not only allows to cope with increasing layers of complexity inherent in such a model system but also provides a framework for the system generalizability to a wide variety of systems. We also use a “physical-machine-like” implementation philosophy and a coding standard integrating the source code with parallel detailed documentation that increases transparency, replicability and reusability of this model system.

The cognitive architecture of the organism is based on a set of motivational (emotional) systems that serves as a common currency for decision making. Then, the decision making is based on predictive assessment of external and internal stimuli as well as the agent’s own motivational (emotional) state. The agent makes a subjective assessment and selects, from the available repertoire, the behavior that would reduce the expected motivational (emotional) arousal. Thus, decision making is based on predicting one’s own internal state. As such, the decision-making architecture integrates motivation, emotion, and a very simplistic model of consciousness.

Improving understandability of complex agent-based model systems

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Agent based models (ABM) are widely used in such diverse areas as social sciences, biology, geography, finances, traffic control etc. Their main power lies in accounting for complexity, irreducible and emergent effects. Unlike traditional mathematical and optimization models, in which a single (or a few) equations are mapping the relationships between the input and output variables, ABM are based on numerous procedures inherently involving lots of equations. In a sense, ABM can be represented as sophisticated “software machines” rather than traditional “simple models.”

Recent and ever increasing progress in the computer hardware and high performance computing enables development complex software systems. There has also been a significant progress in the computer science, especially object oriented methodology, parallel processing, studies on computability and algorithmic complexity. Increasingly more sophisticated software systems are being developed, formally validated and tested. This translates into a tendency to develop ever more complex ABMs, without a parallel effort to develop methods that improve human understanding of complex software or natural systems. We are at a point where increasing algorithmic complexity and sophistication cannot be easily absorbed by the users and even developers of these systems. Human understandability of complex models (and complex systems in general) is becoming a serious factor hampering further development. The understandability problem also limits communication between developers and users, model verification with respect to observed data, reusability of models and their components. Models and computer systems that are difficult to understand cannot be trusted, especially when the potential cost of failure is high. Development of a human-oriented, in contrast to the machine-oriented, computer science is becoming increasingly necessary.

Another important issue for research in ABM is model reproducibility and replicability. The potential for independent investigators of replicating a study using alternate methods and equipment represents the gold standard by which any scientific claim is evaluated. Current publication norms require that all pertinent details of the methods needed to independently replicate a study should be described. The recent decade witnessed an increased interest in so called reproducible computational research in bioinformatics and statistical modelling. All details of computations, including code and data are made freely and easily available for others. Moreover, there should ideally be a script (or makefile) enabling others to repeat the main computation steps automatically and get the same results. However, this issue has not yet attracted a wide attention in the ABM literature. Replicability of the model is a more general construct requiring that it should (at least in theory) be possible to reconstruct the model code from detailed conceptual descriptions (using different computational platforms and implementation details) and get comparable results. Replicability of ABM requires separation of the conceptual model of the phenomena under the study from the specific computer code that implements it. However, if the model and the code are very complex, not easily to understand or communicate, such a separation is difficult if not impossible: the model becomes undistinguishable from a specific (and with high probability buggy) implementation.

As a consequence, there have been continuing concerns in the ABM community about lack of transparency in model descriptions. The most widely used solutions to this problem like the ODD protocol do not descent to the level of the source code and therefore retain certain assumptions and implementation details not well documented. However, small differences in assumptions and procedures can have important effect on the simulation results and their interpretation. In spite of high potential, research using ABM has not been as efficient and widespread as it could be. The power that ABM provide is still poorly used in and cited by the more general, non-modelling empirical research community.

Here we suggest an approach (or philosophy) that is based on what can be called non-perfect understandability, and rooted in human cognitive psychology. Briefly, it assumes that detailed description and complete understanding of the structure and functioning of the whole system is not essential for successfully working with the model, studying its results or developing its components. Some general and relatively vague comprehension involving various lateral cognitive tags and metaphors is sufficient. Only a limited part of the complex system that is the main focus of a specific study at a specific time point—the perfect understandability window—needs to be formalized and comprehended in detail. This allows for some inaccuracies in the perception of less focal concepts without this affecting the overall understanding process. Only a limited part of the whole complex system that is the main focus of the work at a specific time point—the perfect understandability window—needs to be formalized and comprehended in detail. The “perfect understandability window” can shift and shrink/grow to some degree depending on the main focus of the work at any specific moment. A different, but related area where the non-perfect understandability approach can be useful include the use of anthropomorphic, psychological and intentional terms as a tool for labelling complex behavioral and neurobiological phenomena.

In the context of a complex ABM under development—the AHA model that implements a general decision-making architecture in stochastic evolving agents—this translates into a highly modular object-oriented code architecture using concepts and metaphors that are familiar for the intended model audience, developers and users (e.g. genome, chromosome, attention, motivation, emotion, hunger, fear etc.). The code of the model is composed of hundreds of small and simple procedures arranged into hierarchically organized classes and modules. Generic programming, in the form of optional procedure parameters and generic procedures, guarantees that such simple procedures also have high degree of extensibility. Moreover, these procedures integrate both the computer code and extensive detailed documentation explaining the procedures. In a sense, the model code base becomes a document that is primarily directed to the reader and only secondarily, instructions for the machine to execute: there are more human-readable textual information (in form of source code comments), including inline LaTeX formulas and graphs, than the computer-language code. Specific parts of this model (e.g. low level procedures or higher-level modules along with the detailed description) that are within the main focus would fully fit into the understandability window. Therefore, they could be relatively easy to work with and elaborate.

Thus, this approach is based on three main ingredients: (1) object orientation, (2) massive modularity, (3) Knuth's “literate programming” metaphor. The result is that each elementary component of the complex self-evolving system is (a) relatively small and (b) well documented, making it easy to

understand, use and potentially reproduce (e.g. using a different algorithm and programming language). And the same can also be applied to hierarchically higher level program components.

This seems to be a viable philosophy for highly complex ABM. For example, an MSc student with limited software development and modelling experience was able to get into the work and start complex simulation experiments with the model very quickly. The use of the massively modular, self-documenting object oriented approach allow us to isolate complexity into relatively simple tractable and manageable parts and ultimately develop transparent and replicable models of high complexity.

Martin Cenek

New approach to agent based model validation and cross model comparison using the Geometry of Behavioral Spaces Framework

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Keywords: Geometry of Behavioral Spaces Framework, validation, sensitivity study, behavioral prototypes, probabilistic behavioral networks

Iterative construction of high-fidelity Agent Based Models (ABMs) relies on validation of system dynamics using multiple scopes, across multiple drivers, and for all agent dynamics. A common model validation techniques rely on a reductionistic approach that might not guarantee model correctness, completeness, and leaves many possibilities for error. Model verification usually consists of comparison between two 2-D plots of measured model behavior and the corresponding dynamics reported in the data used to construct the model. As an alternative, we designed the Geometry of Behavioral Spaces Framework (GBSF) that abstracts and generalizes common agent behaviors into behavioral prototypes connected by probabilistic links, capturing the likelihood of an agent transitioning between prototypical behaviors. The resulting probabilistic network describes the ABM dynamics on a system level in terms of agent behavior. Non-reductionism of model validation is achieved through this abstract system-level view of model behavior, offering an alternative to pairwise comparison of multiple constituent dynamics. The framework may also be used to study model sensitivity since changes to model drivers are reflected in the agent behaviors. Finally, the GBSF is independent of the model mechanics, allowing us to compare dynamics of two different models of the same problem. We present the GBSF results analyzing idea models of collective behavior, and work in progress analyzing an ABM of Alaska fisheries built to understand the impact of policy and ecology changes to the coupled socio-ecological system.

Casey Day

Utilizing pattern-oriented modeling to calibrate an ABM of animal dispersal

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Keywords: animal behavior; calibration; dispersal; landscape; pattern matching

Animal dispersal is a vital process that connects populations across landscapes and contributes to demographic and genetic population viability. Habitat fragmentation due to land-use change and climate change affects the permeability of the landscape and therefore alters dispersal processes. Managers of sensitive species are in need of tools that can forecast how landscape change will affect animal dispersal, and therefore affect population viability. We developed an ABM to simulate the dispersal and home range establishment of the American marten in northern Wisconsin, USA. The ultimate goal of the ABM was to provide managers with a model to assess the effects of alternative scenarios of land-use and climate change on marten dispersal and population connectivity. To calibrate the model, we used a pattern-oriented approach by comparing model outputs to data collected in the field from actual marten movements. These patterns included dispersal distance, time to home range establishment, dispersion metrics, and sex-based differences in movement. However, a number of questions arose during this process: How many patterns should be included? Should all patterns be weighted equally? What statistical method should we use to assess matching? We discuss the implications associated with using alternative methods during the process of pattern-oriented modeling. In particular, for models with direct management implications, we suggest that the specific context and purpose of the model should be taken into account when deciding how to assess model calibration and pattern matching.

Marcela Gomez

Agent-based Models for Spectrum Sharing

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Keywords: Spectrum Sharing, Spectrum Markets, Spectrum Governance, Polycentric Governance, Agent-based Modeling.

The main focus of our research has been the study of markets for electromagnetic spectrum and the application of governance mechanisms that permit the sound development of spectrum sharing. In general, in spectrum sharing scenarios, we rely on the interplay and interactions of multiple participants. The results in terms of market viability, as well as enforcement opportunities are a consequence of the characteristics of the participants and the rules governing their behavior. For this reason, we have found agent-based modeling as a suitable tool in the development of our research.

In the case of spectrum trading, defining market participants as agents interacting in multiple scenarios has been key for our market analysis. Additionally, through ABM, we have been able to explore the generation and impact of transaction costs, and define the key market configurations that lead to market liquidity. Regarding spectrum governance, we have developed simple agent-based models that permit us to test how polycentric governance methods can be implemented in spectrum sharing environments. The aforementioned characteristics are rather difficult to capture when using traditional tools.

For the purposes of our research, we have utilized multiple agent-based modeling tools such as Repast Simphony, MATLAB and NetLogo. We have chosen these platforms due to the data, analysis and presentation requirements of our work; nevertheless, regardless of the ABM tool, the versatility of our models has remained. Indeed, we have been able to modify them to fit cases of interest, thus ensuring the evolution of our research. To conclude, it should be noted that the scope of our research and the suitability of ABM in this framework suggests that these models can be a key asset toward analyzing areas where technology, economics and regulation converge.

Timothy Haas

Finding Politically Feasible Conservation Strategies: The Case of Wildlife Trafficking

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Keywords: agent decision making, individual based models, rhino poaching Submitted for consideration as an oral presentation

Conservation managers work within a political-ecological system when they develop and attempt to implement a conservation plan that is designed to meet particular conservation goals. We develop a decision support tool that can identify a conservation strategy for a managed wildlife population that is both sustainable and politically feasible. We build, fit, and use our tool on the case of rhino horn trafficking between South Africa and Asia.

As part of our tool, we build a simulation model composed of interacting influence diagrams (Bayesian belief networks with decision nodes) that model the decision making process of each group (agent). These groups include poachers, trafficking middlemen, Asian rhino horn consumers, and anti-poaching units. Rhino population dynamics is captured with an individual-based model derived from ecological theory that explicitly tracks through time every rhino in South Africa (about 10,000).

This interacting political-ecological model is statistically fitted using minimum simulated Hellinger distance to observations on group actions and data on rhino abundance.

This fitted model is then used to compute a politically feasible conservation strategy by finding parameter values that characterize group belief systems that are minimally different than the statistically estimated values but for which the decisions made by these groups are altered just enough to cause the wildlife population to be sustainable.

Maria Hansen

A dynamic structural approach to home and job location decisions

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Keywords: Structural estimation, Dynamic Equilibrium models, Transaction costs, Commuting, Location choices, Urban Economics.

This paper develops a dynamic structural model of the joint decisions on residential location, whether aiming for being employed and if so where to work at the household level. It is a finite horizon equilibrium model with house prices as equilibrium objects which reflect the expected supply and demand of homes in the regions. The model is dynamic in the sense that the household decides at each age whether it wants to move to another place regarding home and job location. This decision is made by taking into account and forming expectations about both household-specific characteristics and location-relevant, potentially time-varying, amenities. The household is subject to region- and individual-specific unemployment risk, but work regions also differ in terms of income potential and commute time dependent on the home region. The model is particularly useful for analyzing counterfactual policies on infrastructure in- vestments to see how these affect households' willingness to commute and how sorting on household characteristics and equilibrium prices on the housing market are affected. The goal is to apply this model to very rich Danish administrative data on the entire population of Denmark since 1992 and to exploit that house prices are observed in these data for the universe of transactions on the housing market. However, in the current version of the paper I do not take the model to data but simulate a simplified version of it for three home and work locations and show that commute costs are important for explaining differences in housing prices across regions.

Jeffery Hepinstall-Cymerman

Using agent-based models to support conservation of a threatened species Authors and

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Keywords: Gopher Tortoise, Georgia, Individual-based model, fragmentation, landscape ecology

Habitat loss, fragmentation, and degradation has led to an estimated 80% range-wide decline of gopher tortoise (Gopherus polyphemus) populations across the Coastal Plain of the southeastern United States. Recently, the gopher tortoise has been proposed as a candidate for federal listing under the Endangered Species Act for its eastern populations. As land owner incentive programs are implemented and the state makes land acquisition decisions to manage gopher tortoise habitat in an already fragmented landscape, an understanding of dispersal ability and landscape connectivity is both important and timely to sustain gopher tortoise populations in perpetuity. However, threatened/endangered species are often understudied, and it is often not possible to do large-scale manipulative studies to better understand the ecology of these species to inform management decisions and conservation actions. An agent- based modeling approach was implemented to simulate the actions and interactions of autonomous agents, in this case gopher tortoises, and their environment using known animal locations and environmental characteristics related to habitat suitability and barriers to movement. This allows system dynamics to emerge from the collective behavior of individuals obeying simple rules, which are based on a combination of quantitative data, qualitative data, and expert opinion. Currently we are analyzing tissue samples to determine genetic relatedness to compare landscape and genetic connectivity and refine movement rules to predict connectivity in gopher tortoise populations across its range in south Georgia. Our work demonstrates an implementation of an individual-based model to understand the genetic connectivity of real and simulated gopher tortoise populations under varying levels of habitat fragmentation.

Richards Iles

Cognition and rationality in poverty: incorporating psychology and economics in an ABM to understand the role of livestock in village-based poverty dynamics

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Keywords: Dual-processing, poverty alleviation, asset transfers, village, India

Rationale: The use of asset transfers to households in absolute poverty has become a popular mechanism towards alleviating poverty. Livestock, as a transferable productive asset, is one particular class of asset that has been studied for its effects on alleviating absolute poverty (Banerjee et al., 2015; Meager, 2016; Randolph et al., 2014). However, long-run effects of transferring livestock to and across poor households is not measured in short-run impact evaluation study designs.

Objectives: This study seeks to better understanding the long-run economic dynamics of livestock asset transfers as they effect households' economic well-being in rural north India.

Methods: A dynamic process classifies decision-makers as being a) rational economic or b) heuristic agents (Kahneman, 2011). A recursive process is developed that classifies agents depending on the level of economic stress experienced (relative to poverty line), which lowers short-term cognitive bandwidth (Mani et al., 2013). Causes of financial stress include household factors (crop yields, health status - human and livestock) and kin-network pressures. Rational economic agents optimize their agricultural inputs (Duflo et al., 2010), while heuristic agents do not. As an extension, increases the time horizon to allow: human capital development (Marsh et al., 2016), cyclical environmental shocks and intergenerational wealth transfers.

Data: Data informing the modeling include: i) qualitative case study data of smallholding goat farmers in Odisha, India (2016), ii) quantitative impact assessment of livestock asset transfers in West Bengal, India (2007-8) and iii) longitudinal household data - socio-economic, human and livestock health - from rural Kenya (2013-16).

Zhu Jin

Using Ontology for Structural Validation of Agent-based Models

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Keywords: Structural validation, ontology, agent-based model, model hierarchy, urban health dynamics

Structural uncertainty, in terms of the diversity of potential model structures that can be constructed for dynamic simulation, provides flexibility in experimental design but poses a particular challenge in ensuring structural legitimacy of a given agent-based model. The problem of structural uncertainty arises from the absence of standard principles with which to design an agent-based model, particularly in terms of nested levels of hierarchical structure that are encoded in the model. The premise of this study is that in addition to statistical hypothesis-testing methods, ontology can provide a structural foundation for agent-based models that establishes their correspondence with reality and facilitates model design and interpretation both quantitatively and qualitatively. This study develops an ontology for agent-based modeling to systematically constrain the space of logical possibilities for alternative model structures, as well bound errors on different levels of the model hierarchy. To illustrate how an agent-based model may be designed from ontological principles, a spatially-explicit agent-based model is constructed to simulate urban health dynamics for contagious disease. This model extends the classic SIR (Susceptible-Infected-Recovered) epidemiological model with ontological definitions of model components and interactions. This study thereby demonstrates how ontology can provide a kind of structural validation for agent-based dynamic models at both individual, aggregate and system scales. As a novel approach to simulation modeling, this ontology confers benefits in terms of reducing complexity of information and easing implementation.

Jeon-Young Kang

Using local spatial pattern and population-level outcomes to calibrate agent-based models of dengue virus transmission

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Keywords: spatial statistics, pattern oriented modeling , calibration, dengue , disease transmission

Agent-based models are increasingly used to examine the efficacy of health interventions and to develop efficient and effective public health policy. Several research groups have developed models of dengue virus transmission to understand the potential effects of vaccine use and vector control. The parameters for these models have been calibrated based on seasonal patterns of illness and population-level infections rates. Many observational studies have determined that dengue virus infections are spatially and temporally clustered within households and among close neighbors. However, these findings have not been used as a touchpoint for model calibration or validation. Our validation efforts with models parameterized similarly to previously published models did not reproduce the level of local clustering that is commonly observed. This has important implications beyond model correctness. Given that dengue control efforts have been and are likely to be applied heterogeneously among households and populations, a model that reproduces observed local clustering is vital for accurate assessment of dengue interventions. Here we employ a pattern oriented framework that uses both population level infection rates and local spatial pattern of infections to calibrate the model. The parameters regarding mosquito population density, mosquito behavior, and virus introduction rates that reproduce realistic local clustering of dengue virus infection are well outside the range of previous models. This illustrates the importance of considering spatial pattern for model validation. Our spatial-statistics-based framework may also be extended to employ measures of space-time patterns of events, such as the space-time k-function, for model calibration.

Andy Keeler

An Agent-Based Model of Social and Economic Determinants of Community Adaption to Sea Level Rise

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Keywords: climate change, adaptation, economics, social updating

Adaptation to climate change in coastal areas depends on multiple climatic, policy, and individual choice drivers that interact in complex ways under significant uncertainty.
Building on our work in McNamara and Keeler 2013, we employ a model that focuses on individual characteristics and their evolution to investigate the way that different factors affect the timing of communities' transition from defense against increasing climate risk to relocation or other discontinuous adaptation strategies. Our model uses fairly simple representations of climate change (flood and erosion damage risk), national-level policies (hazard insurance) and local policies (flood and erosion protection engineering) as key drivers of choice about real estate decisions. The agent-based engine of our model is based on heterogeneous agents interacting both in markets and in their formation of risk assessments. Heterogeneity is characterized by differences in subjective assessment of climate risk (reflecting observed differences in belief in scientific prediction) and wealth. We follow Deffuant, G. et al., 2000 in having agent's update their beliefs about climate risk through random interactions with other agents of similar belief. Agents form and update their valuation of property as a function of policy variables and their own risk assessments. The way in which social updating takes place interacts with the model's other elements to provide indicative results about the way public policies affect adaptation choices and outcomes as a function of different patterns of agent behavior.

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Ryan Kelly

Not So Secret Agents in Long-term Care Facilities: Application of an Agent-based Model to Compare Norovirus Intervention Strategies

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Annually, human norovirus (HuNoV) causes up to 21 million cases of foodborne disease in the U.S. Most reported HuNoV outbreaks occur in situations in which there is a high probability of contact due to living conditions. Not surprisingly, long-term care facilities are among the most commonly reported settings for outbreaks. Although adverse health outcomes associated with HuNoV are believed to be related to poor personal hygiene, the spatial and temporal dynamics of disease transmission are not well understood, making intervention strategies difficult to evaluate. We developed the On- line Predictive Tool to Investigate Mitigation Alternatives for Norovirus (NorOPTIMAL), an agent-based model that simulates the spread of contamination and disease in a long- term care facility. The model represents the interactions between agents and the microenvironment, as well as the interactions among human agents under different behavioral assumptions. NorOPTIMAL serves as a virtual laboratory for both risk assessment practitioners and students to investigate the interactions among multiple risk factors (e.g., poor personal hygiene, aerosolized viral particles). To demonstrate the utility of NorOPTIMAL in a decision-making context, a hypothetical case study was created that compared different intervention strategies for reducing foodborne contamination and spread of HuNoV. Notional results from the case study suggest that the most cost-effective approach to reducing disease burden is a multi-option intervention strategy including, for example, adoption of best sanitation practices for areas impacted by a vomiting event, rapid response training to limit residents' exposure to aerosolized virus particles, and increasing compliance with personal hygiene requirements.

Jennifer Koch

A combined ABM-CA approach for analyzing effects of peer-influence and landowner decision-making processes on urbanization patterns

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Keywords: urbanization; integrated modeling; FUTURES; decision making; peer influence;

In many parts of the U.S., population growth combined with continued demand for low-density housing is transforming the structure of peri-urban landscapes. Despite the substantial amount of privately-owned land, the decision-making roles of individual landowners in shaping patterns of urbanization is understudied. We introduce a simulation model for analyzing the decision-making processes that determine spatial characteristics of fragmentation in peri-urban areas. The model combines the utility of a cellular automata urban growth algorithm (CA module), based on the FUTURES model, with an agent-based model (ABM module). The CA module is conceptualized as a 'developer' in the urbanization process and responds to demand for development by selecting candidate locations based on site suitability factors. The ABM module is composed of landowner agents categorized by typologies of willingness to sell (WTS). Agent WTS controls the ability of the CA module to convert a selected location to a new development. The model is designed to explore how heterogeneous landowners and their values, social and environmental factors, and peer neighborhoods influence landowner decision-making and consequently urbanization patterns. To test the spatio-temporal functionality of our model, we applied it across Cabarrus County, North Carolina. Simulation results demonstrated variation in spatial patterns of urban growth depending on the strength of peer influence on agent decision-making. These simulations contribute to further description of processes underlying emergent urban growth patterns in heterogeneous landscapes and mixed ownership characteristics.

Kenan Li

Introduction to an open-source python platform for agent based modeling in coupled natural and human systems

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Keywords: ABM, Cellular Automata, GIS, Coupled Natural and Human Systems, Geo- simulation.

This presentation presents an open source python platform for building agent-based models and simulations (ABMS). It targets the modeling of complex systems such as the "coupled natural and human systems" and uncovering the coupled relationships within them. Unlike other general toolkits for ABMS, it leverages the advantages of python in data sciences, and is specialized in modeling the spatially explicit agents in the real world. In this platform, users can easily instantiate different types of agents directly from shapefiles (road maps, census boundaries, etc.) or other datasets. Users can easily add, remove, and modify the agents in the shapefile format.

The locations of the agents as well as their other attributes can be exported as shapefile at any time step. Simulation rules derived by machine learning models built based on real-world data can be updated on-the fly. The parameter tuning can be optimized either by exhaustive grid search or randomized parameter optimization to make sure the whole process is best calibrated to the real-world data. Viewing interfaces are developed to offer deep inspections on the agents by 2D or 3D displays of the key statistics of the results. The platform will greatly facilitate the researchers in the ABMS area by offering them an integrated platform.

Sheng Li

The dynamics of the relative importance of the different respiratory transmission modes in environmentally mediated influenza transmission

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Backgrounds: Influenza is associated with pandemics and annual epidemics. Multiple transmission modes for influenza infection have been identified by different studies. Both respirable air transmission and large droplet transmission mode have been suggested to be possible dominant transmission mode. A critical issue of influenza pandemic planning is to implement appropriate intervention strategies that can target the dominant transmission mode specifically. However, previous studies constrained to cumulative infection data collected at the end of influenza epidemics, and the temporal dynamics of the relative importance of different transmission modes were ignored.

Model: An environmentally mediated influenza transmission agent-based model was developed to simulate theoretical influenza outbreak dynamics inside a single abstract venue such as business building, dormitory or house. Model components include discrete individuals, pathogens, and raster environment units. The temporal dynamics of relative importance of multiple influenza transmission modes during different stages of influenza outbreaks were explicitly explored. Environmental dissemination process and persistence process were examined to be the underlying mechanism for the temporal dynamics.

Results: the temporal variation of the relative importance of different transmission modes over the course of epidemics can be observed in all modeling scenarios. This work shows that environmental processes significantly mediate and alter population infection transmission dynamics. The results are of great public health significance, because it is unwise to simply exclude some intervention strategies specifically targeting some transmission modes that are less important at the end of epidemics.

Yan Li

Application of Agent-Based Modeling in Chronic Disease Prevention: The Promise and Two Specific Examples

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Keywords: Agent-based modeling; cardiovascular disease; lifestyles; social norms; food policies

Many countries around the world face an increasing burden of chronic disease that includes heart disease, stroke, diabetes, and obesity. For example, nearly half of the adult population in the United States has at least one chronic health condition. Chronic health conditions are also costly to health care delivery and public health systems, and there is an urgent need for public health leaders, health care providers, and policymakers to find solutions to address this challenge and improve population health. Agent-based modeling (ABM) is a promising systems science approach that can be helpful to model complex chronic disease processes. ABM can capture both dynamic disease progression and the impact of changing lifestyles on the development and consequences of chronic disease. In this study, we discuss the promise of ABM for informing and improving decision-making in chronic disease prevention. We present two ABM examples from our own research to demonstrate this promise. Our first example is an ABM of cardiovascular disease that has been used to prioritize lifestyle interventions across populations of different ages and geographic locations. Our second example is an ABM of dietary behaviors that has been used to evaluate the impact of different food policies on the consumption of a healthy diet in New York City. We provide technical details (i.e., human decision rules, validation, and sensitivity analyses) for both ABM examples and present numerical results from simulation experiments. Finally, we also identify opportunities and challenges for using ABM in chronic disease prevention.

Emilie Lindkvist

In-between empirics and theory: The case of modeling archetypical small-scale fisheries in Mexico

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Keywords: Intermediate complexity, middle-range theories, sustainability sciences, social- ecological systems, self-governance arrangements

Improved governance of small-scale fisheries (SSF) in developing countries is essential to reduce poverty and secure livelihoods for millions of people. To realize this expectation, a better understanding of existing governance arrangements is critical. While general theories of governance of shared natural resources are well established, theories that are sensitive to context, e.g. the social and ecological conditions in SSF, are less developed. We aim to address this gap by combining in-depth qualitative research with literature on SSF in Mexico to inform an agent-based model. Our model comprise a fish stock harvested by fishermen, fish buyers, daily fishing activities, as well as informal institutions of self-governance which rely strongly on trust. Our model results show that existing levels of trust and diversity among fishers matter for successful self-governance arrangements, and should be accounted for when developing better targeted policies for improved SSF governance. The challenge in building this model was finding a middle ground between an in-depth case study model vis-à-vis a theoretical model. We approached this by synthesizing different sources of empirical data and literature of SSF in Mexico. The challenge was to translate those findings into key model processes (e.g., how fishers obtain means to go fishing and to whom they land their catch) rather than model parameterization, while maintaining scientific validity. The goal of participating in the ABM17 symposium is to discuss these issues and find ways forward to build middle-range theories using agent-based models, especially for moving sustainability sciences and coupled human-natural systems theory forward.

Nicholas Magliocca

The Role of Subjective Risk Perceptions in Shaping Coastal Development Dynamics

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Keywords: Agent-based modeling; natural hazards; vulnerability; behavioral theories; land-use change.

In highly dynamic socio-environmental systems, particularly those affected by frequent natural hazards, the ways in which people perceive their environment, formulate expectations of risk, and make decisions influence the long-term vulnerability of the built landscape to natural hazards. A common observation in landscapes prone to natural hazards, such as flooding and/or hurricanes, is the emergence of overly reactive (i.e., out-of-equilibrium, or 'boom-bust' cycles) market dynamics. Housing prices and insurance uptake rates have been shown to decline and spike, respectively, immediately after hazard events and then return to long-term trends as time since the event increases. Theoretical explanations for such dynamics typically point to psychological factors, but conclusive evidence is difficult to extract from empirical data alone. Here, we use an economic agent-based model (ABM) of coupled housing and land markets (CHALMS), adapted to a coastal setting, or C-CHALMS, to investigate the explanatory ability of alternative decision-making models to explore potential behavioral mechanisms driving such reactive market dynamics in response to coastal storm events: a) full information versus dynamic subjective risk perception, and b) utility maximization versus salience theory. A novel 'building-block processes' approach, which combines pattern-oriented modeling (POM) and a hierarchical genetic algorithm, is used to simultaneously select and calibrate the set of decision rules and parameter values that most accurately reproduce empirical housing price dynamics and insurance uptake rates. Our modeling results provide tentative support for the increased importance of psychological factors as drivers of reactive market dynamics as coastal hazards become more frequent.

Fraser Morgan

Indigenous people and Ecosystem services – another approach to land-use decision- making in ABMs?

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Keywords: Ecosystem services, land use, indigenous, decision making

The ownership of significant parts of New Zealand have been, and continue to be, returned to Maori ownership through a settlement process (Treaty of Waitangi). Existing NZ- focused models of land-use/land-cover change (LULCC) has assumed that Maori-owned land was operated to maximize their profit within strict environmental limits (sometimes more strict that non-Maori). Recent research into the management of Maori-owned land has highlighted significant differences in the decision-making process applied when making land-use decisions. Using detailed interviews, focus groups, and a national land owner survey, we see that Maori focuses more on a holistic world view that will highlight the effects of a decision on a variety of factors, with profit and the environment being just two. After review, we have found that this decision-making approach aligns well with an ecosystem services perspective that documents and accounts for the various ways in which ecosystems provide benefits for the community (through supporting, provisioning, regulating, and cultural benefits). Consequently, we have begun to embed an ecosystem services framework that accounts for the changes in services based on a changing land-use, and enable these indigenous agents to utilize them within their decision- making process. We also propose that this framework might be more relevant than existing applied approaches to decision-making for a range of agent types within ABMs of LULCC.

Birgit Müller

Human decision making in ABM – theoretical foundations, frameworks and documentations

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Keywords: human decision, theoretical foundation, social-ecological systems, protocols

Careful consideration of human decision making is a prerequisite for using agent-based models to understand and manage coupled human-environmental systems. However, in a review on ABMs in land use we show that models of human decisions are mainly not theory-based. If so, they are grounded to a large extent on classical economic theories and rarely on psychological ones, which include behavior in a more realistic way (Groeneveld et al. 2017). These findings induce that the full potential of ABMs to incorporate factors such as social norms, learning and adaptation is by far not tapped.

To facilitate a broader inclusion of theories on human decision-making, we provide the framework-MoHuB (Modelling Human Behavior) (Schlüter et al. 2017). The framework is aimed to serve as tool to support formalization of theories as well as their comparison and communication in model-based studies.

We illustrate the application of the framework by a multi-agent model on natural resource management in drylands. The purpose of the model is to provide a better understanding of the social-ecological consequences of behavioral changes (such as giving up of a social norm) of pastoral households. Three household types are implemented which differ in their preferences for livestock, how they value social norms concerning pasture resting and how they are influenced by others' behavior.

Furthermore we will present that the use of standardized protocols to describe the human decision model such as ODD+D (cf. Müller et al. 2013) has proven to be beneficial for improved transparency, reuse and hence advancements of ABMs.

Okan Pala

Water Treatment Plant Service Area Estimation using Agent Based Modeling

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Keywords: Critical infrastructures, water utility networks, distribution modeling, service area estimation, geospatial

Critical infrastructures (CI) such as electrical power grids and water distribution systems, involve multi-dimensional, highly complex collections of technologies, processes, and people, and as such, are vulnerable to potentially catastrophic failures and cascading effects with escalating impact across multiple infrastructures. Understanding the impact of service outages in these systems is a key part of decision-making in response and recovery efforts. With increased use of solar and wind systems for power and private wells and distillation units for water, new modeling implementations are needed to account for the expansion of these now centralized systems more towards distributed systems.
We are in early stages of research that investigates the use of Agent Based Modeling (ABM) along with Geographic Information Systems (GIS) to implement accurate estimation of service areas for distribution sources such as power substations and water treatment plants (WTP). This information is essential to create accurate simulations to be used as a part of decision support solutions for CI outage recovery.
In this study we model the service areas for WTPs in select areas of Kentucky water distribution system. We use existing ABM tools along with open source GIS tools to estimate spatial extent of the demand assigned to each WTP. The agents used for service area estimation are created for different demand types (domestic, industrial, commercial) and optimized on the road network travel distance ending when sources are depleted or all demand points are allocated. In this poster we will present the details of our implementation and early results.

Francesco Pizzitutti

Out of the net: an Agent-Based Model to study of the effect of human movements on local-scale malaria transmission

Francesco Pizzitutti[1,2], William Pan[2] and Carlos F. Mena[1]
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Malaria is far from being globally eradicated. Nevertheless, malaria control programs have produced remarkable results in reducing global prevalence producing at the same time noteworthy malaria epidemiological changes. Recent studies showed that spatial and social heterogeneities, in low-transmission settings, have an increased weight in shaping malaria micro- epidemiology. New techniques have to be considered to tackle the problem of malaria control, to propose new solutions and to test integrated control strategies. We present a set of Agent-Based Models to study the effect of local-scale human movement on malaria transmission in a typical amazon environment dominated by rivers flooding. Two communities in the Peruvian Amazon are selected based on the spatial distribution of households. The ABM simulations evidence that the overall malaria incidence essentially is not influenced by human movements but high risk spatial hotspots, as calculated trough the SatScan method, depend heavily on it. When considering human movements malaria hotspots are centered not only on households but also on the location of farms were farmers work during the day. The human movement models are then used to test the effectiveness of malaria control strategies focused on the reduction of local-scale malaria incidence trough the elimination of hotspots. Two kinds of scenarios are tested. The first scenario consists in treating people that enter inside hotspots revealed considering all actual sites of infections including farms. The second scenario involves the treatment of people entering in hotspots calculated as if all the infection sites were located in households where infected agents inhabit. Simulations show that both the considered scenarios perform better in controlling malaria than a randomized treatment of individuals.

Alenka Poplin

Modeling human behavior in the built environment: An integration of a Game-based Simulation and Agent-Based Modeling

Alenka Poplin and Caroline Krejci, Iowa State University

Keywords: human behavior, energy, game-based simulation, agent-based modelling

Our research concentrates on understanding human behavior in the built environment regarding energy use. In particular, we are developing an agent-based model (ABM) that will serve as an experimental testbed for policies and interventions that are aimed at reducing urban residential energy consumption while maintaining human comfort. The decision processes, behavior, and interactions of the agents in the model will be informed by empirical data collected via surveys, interviews, observations, and a game-based simulation. We are in the process of developing the game-based simulation of a residential building, in which the player explores the built environment and makes energy-related decisions. The game includes randomly-generated events that represent real-world situations, such as a heat wave, a cold snap, or a significant energy bill increase. The software then records the player's responses to these events. We hypothesize that we will be able to detect patterns in the collected data, which will give us a better understanding of the ways in which humans modify their behaviors in response to different environmental and social stimuli. These patterns will be statistically analyzed, and the results will be used to construct personas. The personas will then be used to characterize heterogeneous agent attributes and behavioral rules in the ABM. Once the ABM has been fully developed, the data from the game-based simulation will also provide a basis for model validation. The validated model will then serve as a decision-support tool that will assist city planners and government officials in their efforts to improve urban sustainability.

Jundong Qiao

Deep Learning in Individual-Based Modeling: An Application of Convolutional Neural Network in Modeling Fish Path-Choosing Behavior

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Keywords: Deep Learning; Individual-Based Modeling; Computational Fluid Dynamics; Convolutional Neural Network; Fish Path Choosing Behavior

Understanding and predicting how fish make decisions while negotiating a way through fish passage structures is critical for researchers to design and build high efficiency structures. In this study, an individual-based model (IBM) linking a computational fluid dynamics (CFD) model and convolutional neural network(CNN) is proposed to address this problem. The CFD model provides continuous hydrodynamic stimuli in terms of a continuous flow field. A well-trained CNN produces a smart agent that is able to behave in this field like a real fish in hydraulic structures. The smart agent learns the heuristic path-choosing behavior rules from a set of real fish experiences, which is in the form of "stimuli-response" pairs. The stimuli are fish hydrodynamic sensory cues such as instantaneous velocity, pressure, and turbulence intensity. The corresponding fish movement decisions, such as keeping swimming or turning to avoid unfavorable flow conditions, are made based on the hydrodynamic stimuli. The smart agent is able to sense the environmental variables just like real fish; the fish-preferred 'road map' can be depicted by visualizing the response maps of the hidden neurons in the CNN. Thus, the most salient features that are 'picked up' by the CNN would be the most important 'makers' that can guide a fish migration in a passage structure. The 'markers' can be created intentionally by researchers in the design of fish passage. The broad application of CNN in IBMs is to establish intelligent agents capable of abstracting heuristic mechanisms of animal behaviors.

Mark Rouleau

ForestSim: An ABM Simulation of Bioenergy Sustainability

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Michigan Technological University

Keywords: sustainability, bioenergy, land-use, forest management, and simulation

Bioenergy from woody biomass (trees and other woody plants) presents a promising alternative to conventional fossil fuel. In heavily forested regions, bioenergy can reduce harmful carbon emissions, increase economic development, and reduce energy costs. However, the key to successful bioenergy development lies in the sustainable procurement of biomass. Our study uses ForestSim, an agent-based model (ABM) of private forest owners, to conduct a series of policy experiments to assess the sustainability of alternative biomass harvest incentivization mechanisms. We developed this model for the Western Upper Peninsula of Michigan, USA using a series of stakeholder focus groups, semi-structured private forest owner interviews, and a quantitative survey of a random sample of private forest owners in our study region. We used the information from these preliminary studies to design our agent decision-making schema and our sustainability assessment framework. Our model then uses GIS data to embed our private forest owner agents within real property boundaries with the appropriate land cover conditions assigned to each parcel. During a typical simulation run, agents decide whether or not to harvest biomass for our simulated bioenergy market. This decision is informed by current land cover conditions, interactions with neighboring agents, current market conditions, and available biomass harvest incentives. We compare the outcomes of alternative incentivization mechanisms across a broad spectrum of empirically grounded sustainability indicators, including stakeholder generated indicators in the economic, social, and environmental domains of our region. Our model demonstrates the need for complex policy instruments to minimize stakeholder conflict within our bioenergy system.

Bryan Runck

Automatically creating human agents from qualitative data using deep learning

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Keywords: preference formation, Bayesian models, deep learning, natural language processing

Generating replicable and realistic models of human decision making is crucial for the scientific accuracy and overall reproducibility of agent-based models. In order to capture realistic agent preferences, empirically based agent decision heuristics are often hand crafted from qualitative field interviews. While the heuristics-based approach successfully incorporates contextual decision making and heterogeneous preferences and decision strategies, it suffers from a static representation of agent preferences and is difficult to reproduce. Recent evidence from psychology and natural language processing illustrates that a significant number of human cognitive biases can be reproduced using word vectors created with the word2vec model, a new deep learning technique that represents words in a high dimensional vector space.

This poster describes 1) a new method of developing agents from qualitative interview data that utilizes vector spaces to capture individual's "mental models", and 2) a method to deploy the resulting vector space models in a Bayesian framework that enables agents to learn preferences through experience by reinforcement learning.

Preliminary results indicate that this approach generates dynamics similar to that of a hidden Markov model, but with the added potential to capture the path-dependent nature of cognition and memory. Future work will compare this vector space approach to existing prominent approaches according to the Pattern Oriented Modeling framework, with an emphasis on replicating behavioral data from social-ecological systems. If successful at reproducing observed human decision making, the described approach could streamline the creation of empirically based agents from field interviews and improve the reproducibility of agent-based modeling.

Peer-Olaf Siebers

Facilitating Multidisciplinary Agent-Based Social Simulation Modelling: A (More) Formal Approach

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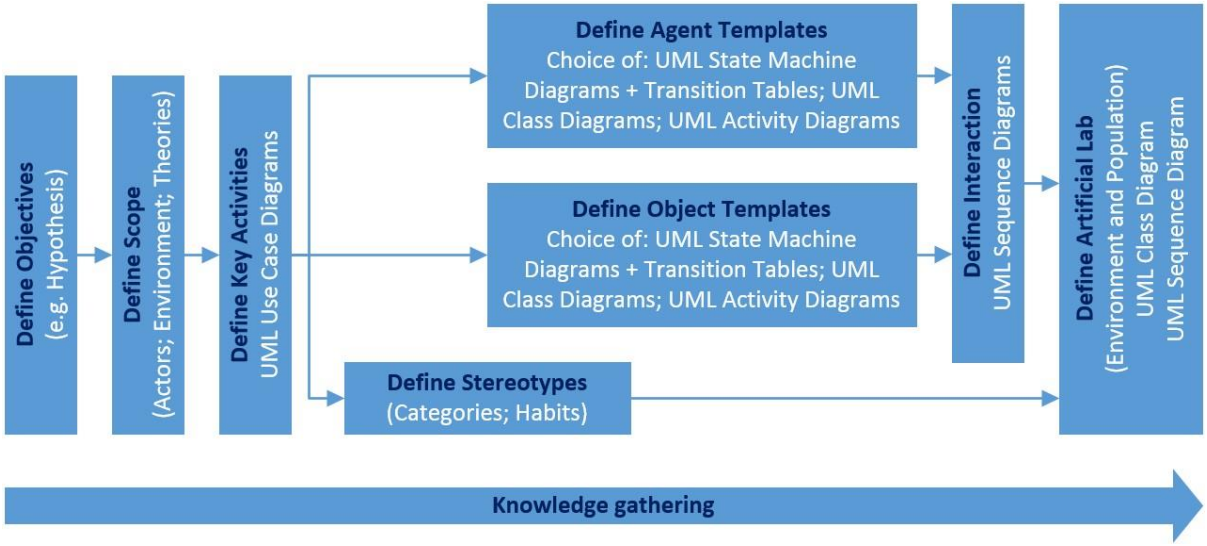
Keywords: Agent-Based Social Simulation, Conceptual Modelling, Formal Approach, UML, Software Engineering

When aiming to develop Agent-Based Social Simulation (ABSS) models one faces the question of how to build them and where to start. This can be challenging not only for novices in the field but also for multidisciplinary teams where it is often difficult to engage everyone in the modelling process. In this case co-creation is an important aspect. Team members need to be open minded about the use of new tools and methods and about the collaboration with researchers from other domains and business partners. Over the years we have developed a quite sophisticated "plan of attack" in form of a framework that guides the model development and can be used by either individuals or teams.



The framework supports model reproducibility through rigorous documentation of the conceptual ideas, underlying assumptions and the actual model content. It provides a step-by-step guide to conceptualizing and designing ABSS models with the support of Software Engineering tools and techniques. While this framework will not work perfectly for all possible cases, it provides at least some form of systematic approach. The user should be prepared to adapt it to fit individual needs.

Our poster explains each step in this framework and exemplifies its application. To demonstrate the use of this framework we provide an illustrative example: studying the impact of normative comparison amongst colleagues with regards to their energy consumption in an office environment.

Charles Sims

Understanding the impact of distributed generation: An agent-based computational economics approach to investigating dynamic human behavior of electric utility customers

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Keywords: electricity markets, Roth-Erev learning, solar energy, real options theory

The increasing adoption of small-scale electricity generation technologies represents a transition from a hub-and-spoke system of centralized generation to distributed generation (DG). Identifying policies that could help smooth this transition requires an understanding of individual utility behavior, the rate and location of DG adoption, and the dynamics of electricity markets.

This study extends existing agent-based computational economics (ACE) frameworks to explore the system dynamic behavior of the electric grid as it transitions to a greater reliance on DG.
Our modeling activities build off the existing Agent-based Modeling of Electricity Systems (AMES) model. We amend the standard AMES platform in two ways. First, we allow customer electricity demand to be sensitive to electricity rates. As customers adopt DG, utilities are forced to raise rates to cover the large fixed capital costs associated with generation and transmission.

Rate increases then increase the electricity costs associated with traditional electricity triggering more DG adoption. In our study, customer demand for electricity is based on electricity sales data from the largest utilities in the New England ISO. Second, we create a new end-use customer agent type that allows us to investigate DG investment behavior. Unlike AMES where customer demand is aggregated to the local utility level, our model disaggregates local utility demand which allows us to investigate how differences in socio-economics and information influence decisions to invest in DG and how these micro-level investment decisions influence macro-level outcomes such as electricity dispatch and pricing.

Grace Smarsh

Improving Acoustic Monitoring Methods of Bat Populations in Heterogenous Environments using Agent-Based Models of Spatial and Vocal Behavior

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Keywords: bioacoustics, monitoring, behavior, bats, communication, echolocation

Acoustic monitoring, the recording of vocalizations of animals, is a popular method of monitoring animal movement, distribution, and population health across spatial and temporal time scales for research and conservation purposes (1). The efficacy of monitoring designs varies by taxa, and is greatly dependent on prior knowledge of the behavioral ecology and vocal repertoires of individuals. In addition, individual behavior is dynamic, responding to changes in social context and the environment (2). With better technology to record the spatial movements of animals across landscapes and their vocal behavior, scientists can now better quantify the behavior of individuals. My goal is to use agent-based modeling of individual vocal and spatial behavior to test improved acoustic monitoring methods in bats.
Acoustic monitoring of echolocation of bats is widely used to assess relative abundance and species diversity in different habitats to monitor their populations for conservation of the species as well as the ecosystems that they ecologically serve (3). However, echolocation pulses are dynamic, difficult to use to tell individuals apart, and are often quite similar across species. In addition, many species of bats use low-amplitude echolocation that is difficult to record in the field (3). Thus, echolocation monitoring has large limitations in its usefulness to track the success of individuals in an area over time. With better technology to study nocturnal bats, researchers have been finding that bats have diverse social-spatial behavior in the field as well as diverse communication repertoires (4). I intend to test our ability to use more informed spatial data and communication repertoires to improve bat bioacoustics monitoring schemes by using agent-based modeling of the heart-nosed bat. This species has individualistic, loud, low-frequency songs and maintains exclusive foraging territories (5). Using agent-based modeling including the movements of individuals on their territories, the individuality of singing behavior, and the individuality of song repertoires, I can test the best methods of monitoring individuals and populations acoustically using passive or active monitoring with point or line transects. The major challenge of this project is incorporating the variability of the song repertoires, which may require machine learning algorithms, and transmission distance of the various signals.

I seek to incorporate environmental data to better predict how individuals adjust their spatial and vocal behavior in an anthropogenically altered or heterogenous environment, and to predict how these behavioral changes influence individual and population success. Ultimately, I hope to make this model modifiable to other bat species, or other taxa such as birds, or frogs.

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Garry Sotnik

Evaluating social components of social-ecological models, using game-theoretic and experimental contexts

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Keywords: agent-based modeling, game theory, social-ecological models, social psychology, and validation

Human adaptation to climate change is being integrated into social-ecological models that are used to explore outcomes of potential climate futures. Multi-agent models are ideal for modeling human adaptation as they not only can simulate adaptation on the aggregate population level, or of one representative agent, but also on the individual level of a population of agents, where agents adapt by sharing, inventing, and choosing among alternative actions. Despite continued progress, standardized methods for evaluating how well simulated adaptive behavior of artificial agents reflects potential human adaptive behavior remain in the stages of early development. This paper reports on the evaluation of the new multi -agent and -network SOSIEL (Self-Organizing Social and Inductive Evolutionary Learning) algorithm, developed to simulate social human behavior in a forest-climate change model. The cognitive processes comprising the algorithm are rooted in theory from artificial intelligence, evolutionary biology, psychology, and sociology. The satisficing SOSIEL agents display common cognitive biases and are capable of anticipatory learning, counterfactual thinking, inductive reasoning, social learning, heuristic selection, and action-taking, which, if they choose, may be collective. The evaluation involves configuring the algorithm for a variety of game-theoretic and experimental economics and psychology contexts that require a varying degree of cognitive complexity and comparing outcomes to respective theoretical predictions and stylized facts.

Yushiou Tsai

The interactive effects of land use patterns, socio-economic status, and social psychological factors on the adoption of best management practices: an application of a land use agent-based Model

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Keywords: Social psychology; best management practices; land use; structural equation modeling; farm level decision-making.

Agricultural best management practices (BMPs) have been used to mitigate non-point source pollution and maintain agricultural productivity. Policy makers have recognized the importance of using government programs to encourage BMP adoption at the farm level. Farmers' decision-making on BMP adoption was implemented into a spatial explicit land use agent-based model (ABM) to examine how BMP adoption barriers would be lowered. We used structural equation modeling (SEM) to fit the data collected from a farmer survey that examined farmers' likelihood of BMP adoption given their socio-economic and social psychological factors. We then incorporated this SEM in a land use ABM. This land use BMP adoption ABM simulates individual farmers' annual likelihood of adopting three BMPs—riparian buffer, cover crop, and reduced tillage. We employed the theory of planned behaviors postulating that BMP adoption likelihood is affected by farmers' social psychological factors: perceived social norm, perceived behavior control, and past practices. One example of the perceived social norms was whether a farmer's friends influence their likelihood to adopt. Perceived behavior control represents the farmers' level of confidence or knowledge of using BMPs. We also postulated that farmers' social psychological factors are affected by their socio-economic factors such as age, education, financial condition, farm size, or conservation easement. The land use BMP adoption ABM is data-driven. It provides an empirical modeling platform that can be used to examine the effects of different government programs on farmers' likelihood of BMP adoption.

Raffaele Vardavas

Perceptions of Income Tax Evasion and Tax Moral: A survey to inform an agent-based model

Keywords: income tax evasion, agent-based model, survey design, social influences, risk perceptions

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Income tax evasion is a problem that poses considerable challenges for tax authorities and governments at the local, state, federal levels, as well as internationally. Its causes and implications are both economic and social, and therefore it is of enormous importance in policy design. We built an agent-based computational simulation model of income tax evasion. Within the simulation, individuals' compliance behavior changes through an adaptation process based on their past experiences with audits and tax evasion penalties, their perception of the fairness in taxation rates and social interactions with people in their social networks. To inform the model we have conducted a survey on a nationally representative sample on the perceptions of tax fairness. The specific purpose of our survey will be to guide the model construction, test our model assumptions, as well as inform behavioral parameter values and the calibration procedure. In addition, the survey will provide novel insights into the social dynamics of risk and fairness perceptions, including how individual perceptions are influenced by perceptions and experiences in an individual's social network and global community. Here, we present our initial findings from our survey and how it informs the simulation model's behavioral mechanisms and parameter values. We will also present initial findings of our model including (i) validation against known stylized facts in tax evasion, (ii) sensitivity analyses that rank each parameter in terms of leverage on overall compliance levels and (iii) model calibration to reproduce US national levels of income tax compliance.

Christopher Weiss-Lehman

Combining agent-based modeling with experimental data to understand the role of evolution in range expansions

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Keywords: Range expansion, evolution, spatial heterogeneity, agent-based modeling, model

Range expansion is a fundamental biological process with important implications for conservation (e.g. invasive species). Recently, research has uncovered the important role that rapid evolution plays during range expansion. In particular, evolution has the potential to drastically increase the intrinsic variability of range expansions. However, it is unknown how rapid evolution during range expansions might interact with other processes known to affect variability in expansions. Landscape structure seems especially likely to interact with spatial evolution during range expansions, but this interaction is difficult to fully capture in experiments or simple, analytical models. Thus, we constructed an agent-based model (ABM) allowing evolution of both individual fitness and dispersal and coupled it with experimental data to examine the interactions between habitat heterogeneity and trait evolution during range expansion. We parameterized the model using published data on red flour beetles (Tribolium castaneum). We then simulated range expansion dynamics through heterogeneous and homogeneous landscapes, varying the strength of evolution in both traits via a heritability parameter. Finally, we compared the model results with independent data from a parallel experiment in the T. castaneum system. Both model and experimental results suggest that habitat heterogeneity dampens the effect of spatial evolution on variability during range expansions. The model indicates this is due to the role of evolution as model simulations with heritability of both traits set to zero show the opposite pattern. Thus, by combining our theoretical ABM with experimental data we have provided rigorous, mechanistic insights into the role of evolution in range expansions.

Roy Williams

High-fidelity geospatial ABM of human-environment interaction in oceanic fisheries

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Keywords: fisheries, high-performance, human-decision-making, geospatial, graphics

We created high-fidelity agent-based model of oceanic fisheries that allows us to test various hypotheses about the role of decision-making and communication in fisheries. We plan to use this ABM to investigate commercially important fisheries that exhibit a variety of spatial population density profiles, from densely distributed slow moving bottom dwelling species (lobster) to the fast moving, tightly schooling tuna that are sparsely distributed over the eastern Pacific. We have used this ABM to test a hypothesis that information sharing has little impact on harvest outcome in the Gulf of Maine Lobster Fishery (the model includes 6,500 active Lobster boats, and the entire lobster population of the Gulf over 80,000 square miles, at a resolution of 1,600 feet). We found that captains making decisions about where to set traps based solely on their own recent experience do no better than captains who pick fishing locations randomly, but captains who obtain the results of other boat's previous day's catch obtain 11% more landings with the same quantity of trap sets, and the advantage varies by the count of boats with which the captain communicates.

In addition to modeling human decision-making in an environmental context, our ABM uses a Google Earth image of the modeled area as the primary interface for user input and validation of operation. Quantitative output is delivered to files that are spreadsheet compatible. The ABM executes a year of lobster fishing, at a resolution of one minute, in less than 2 minutes on a desktop PC.

Shang Wu

Simulating Heterogeneous Farmers under Different Policy Schemes: Integrating Economic Experiment and Agent-Based Modeling

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Key Words: Economic Experiment, Agent-Based Model, Non-Point Source Pollution, Policy Evaluation, Technology Diffusion

Non-point source (NPS) water pollution from agricultural runoff is a leading cause of water body impairments in the United States; however, NPS pollution is difficult to identify and regulate because of hidden actions and asymmetric information. Past economic research showed that ambient based policies could induce groups to reduce pollution to socially optimal levels. However, most of the work was based on economic experiments that are limited in scale and the ability to draw conclusions outside lab settings. In this paper, we develop an agent-based model (ABM) that scales up findings from an economic experiment on technology diffusion and management of NPS water pollution in an actual watershed. The economic experiment features both farm size and location heterogeneity and participant decision space is extended to both production and technology decisions to better reflect the reality. Data from geographic information systems (GIS) and the Census of Agriculture initialize ABM setup. The farm agents operate constellations of farmland parcels that are generated based on a distance matrix calculated from parcel level coordinates and are fitted using size probability density functions to the Ag Census data. Cluster analysis and mixed effects multinomial logit models are used to generate agent types and provide foundation for assumptions and parameters used in the ABM. Experiment data calibrate agent decision rules that determine production and adoption deviations from target level. This integrated model enables us to explore the effects of several different policy interventions on technology diffusion and agricultural production and, hence, on agricultural non-point source pollution.

Ling Xue

Agent-based Simulation of Spatial Evolution of the Polycentric Structure in Metropolitan Area in China

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Keywords: metropolis; polycentric structure; NEG; agent-based modeling; out-of-equilibrium simulation

Since the 1990s, cities in China have experienced a period of rapid growth. In face of the increasing complexity of the urban sprawl, many big cities are planning to build new towns to avoid over-intensive population and infrastructure construction and to ease the pressure on urban centers. Some findings show that the rapid increase of the share of service industries in the local economy can raise the probability of the emergence of subcenters. This paper builds a mathematic model of spatial structure of metropolitan area base on the theory of New Economic Geography in old and new center scenario. By using agent-based modeling and out-of-equilibrium simulation, the spatial structure of subcenters can be observed dynamically in different scenarios. Spatial evolution is path dependence. Dynamic simulations show that(1) Size matters a lot. Population growth in metropolitan area is conducive to subcenters which implies the commercial centers emerged in the suburban area were mostly subjected to population pilot policy. (2) Demand remains important. The continuous growth of demand scale and capacity depend the formation of the polycentric structure in metropolitan area. The capacity of consumptions has outstanding impact on agglomeration of subcenters. (3) Fixed cost and transport cost help a lot. The greater the gap of commercial fixed input between the new and old center is, the more imbalanced urban space distribution would be, and more easy to form the core-periphery structure. If the fixed costs are reduced continuously in suburban area, it is beneficial for the formation of subcenters and the core-periphery structure of metropolitan area could be changed gradually. (4) Transportation is a double sword. Commerce and business tend to gather in the place with location advantages, and continuous improvements in traffic condition between old and new center in metropolitan area will accelerate the spatial concentration in old center. The probability of the emergence of subcenters decreases with the increase of the distance to the city center, which implies the subcenters emerged in the metropolitan area were mostly close to the central area of the city and the decentralization of population in the metropolitan area was still limited in spatial scale.(5) Due to love-of-varieties, the specialization and diversity contribute much to the formation of subcenters in metropolitan area by continuous innovation and difference-making competition strategy.

Ethan Yang

Evaluating Water-Food-Energy-Environment Nexus with Agent-Based Modeling Framework

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Keywords: River basin management, water resources, decentralized modeling, systems approach, decision making,

Water-food-energy-environment nexus modeling has the potential to improve our understanding of the interactions between humans and natural systems as they relate to surface water, groundwater, food production, energy generation and ecological issues. This understanding can serve as a foundation for scientifically sound policy advice. In most of my previous research projects, I used agent-based models to simulate the interactions among these four sectors and framed modeling results to inform resource management decisions. Agent-based models evaluate the behavior of autonomous "agents," such as individuals, farms, power plants, habitats and/or institutes. Agents make decisions in their own self-interest based on behavioral rules that incorporate economic, social and environmental factors. Within the model, agents can influence and be influenced by other agents. This agent-based modeling approach is an excellent fit for the complex, multi-scale administrative structures associated with water, food, energy and environment management. The method also has the potential to transition efficiently between local and regional scales. Because of its decentralized nature, agent-based modeling can evaluate the influence of micro-level decisions on macro-scale phenomena, and can shed light on collective responses to changing environmental conditions and policies. It can also be used to understand the resilience of existing systems and quantify the effectiveness of adaptation strategies that developed spontaneously in multiple sectors. Case studies of applying agent-based modeling framework for water-food-energy-environment nexus in the Yellow River Basin in China, the Mekong River in Southeast Asia and the Niger River in West Africa will be demonstrated in my presentation.

Quiyi Zhang

Sensitivity Analysis of an Agent-Based Model of Healthcare Accessibility

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Keywords: Agent-Based Modeling, Sensitivity Analysis, Healthcare Accessibility, Visualization, Geographical Information Science

This study analyzes simulation results from an agent-based model (ABM) of healthcare accessibility to recognize and evaluate patterns of dynamic behavior using sensitivity analysis. In this model, older adults living in the East Harlem neighborhood of New York City are simulated as mobile agents who visit community centers and dental clinics, where they receive preventive screenings and treatment. Sensitivity analysis is performed to reveal how simulated health outcomes vary in response to alternative assumptions. Potential inputs to sensitivity analysis include specific model parameters, sets of parameters defined in an agent class, initial conditions (e.g., initial values of state variables), or entirely different model structures. Two types of pattern recognition are considered: visual inspection and a computational approach. The process of sensitivity analysis has 3 parts: 1) testing model stability using fixed parameters with a random seed; 2) testing the variability of model structure in response to changing parameter values with a fixed seed; and 3) testing the effect of each individual input parameter contributes to the variance of the model output. In this study, a variance- based method known as the Extended - Fourier Amplitude Sensitivity Testing (Extended-FAST) is used for part 3 of the sensitivity analysis. Extended-FAST is advantageous for analysis of non-linear and multi-scalar ABMs and it captures the influence of the full range of variation of each input factor. Exploring model sensitivity is necessary to ascertain model robustness, improve model transparency in communicating results to stakeholders, and inform the design of new simulation experiments and model structures.