

## MODELING ANCIENT SETTLEMENT SYSTEMS (MASS)

### Benjamin Studevent-Hickman

The year 2006/2007 marked the fifth year of the Oriental Institute's Modeling Ancient Settlement Systems (MASS) project. In collaboration with Argonne National Laboratory, members of the Oriental Institute and the University of Chicago create agent-based computer models of settlements (and groups of settlements) in Bronze Age Mesopotamia — all toward analyzing their reactions to and development under prescribed conditions. One specific goal of the project is to compare the rise and fall of cities and states in northern and southern Mesopotamia in light of the regions' distinct landscapes; to that end, the models incorporate the fullest possible range of social, economic, and ecological data available from texts, archaeological remains, satellite imagery, geomorphological analyses, and ethnographic studies. A final monograph, entitled *Modeling Mesopotamia: Exploring the Dynamics of Ancient Society* (University of Chicago Press), will present the project's framework and results. MASS is funded by the "Biocomplexity in the Environment" program of the National Science Foundation.

### General Project Developments and the MASS Team

MASS saw several significant changes in 2006/2007. First, the project received a no cost time extension of one year, allowing the team to continue its work through July 2008. Second, McGuire Gibson became the Principal Investigator (PI) of the project in May 2007, replacing Tony Wilkinson, who now teaches at Durham University (Professor Wilkinson remains a Co-PI on the project, along with John Christiansen of Argonne). Third, Tate Paulette, a graduate student in Mesopotamian Archaeology at the University of Chicago and a long-standing member of the project, became the principal liaison between the Oriental Institute and Argonne. His primary

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task now is to oversee the development and implementation of the GUI (pronounced “gooey,” for “Graphical User Interface”), the means by which a user will interact with the model. Finally, MASS hired two new computer programmers, Robert Law II and Nolan Frausto — undergraduate students at the University of Chicago. Their mission is to facilitate the transfer of the model to the Oriental Institute itself so other team members (and, ultimately, the general public) can manipulate the input parameters and run the model on terminals in the building. Members of Argonne will, of course, remain involved in the project, helping the new programmers develop a more comprehensive model of civilization in Bronze Age Mesopotamia.

As of June 2007, the members of the MASS team are as follows:

**Principal Investigators:**

McGuire Gibson, The Oriental Institute, University of Chicago (PI)  
 Tony Wilkinson, Durham University (Co-PI)  
 John Christiansen, Argonne National Laboratory (Co-PI)

**Senior Members:**

Scott Branting, The Oriental Institute, University of Chicago  
 David Schloen, The Oriental Institute, University of Chicago  
 Christopher Woods, The Oriental Institute, University of Chicago

**Computer Modeling:**

Mark Altaweel, Argonne National Laboratory  
 Robert Law II, University of Chicago  
 Nolan Frausto, University of Chicago

**Research Associate/Post-doctoral Fellow:**

Benjamin Studevent-Hickman, The Oriental Institute, University of Chicago

**Graduate Students:**

Tate Paulette, University of Chicago  
 Dan Mahoney, University of Chicago

**Consultants:**

John Sanders, The Oriental Institute, University of Chicago  
 Hermann Gasche, University of Ghent

**Active Members:**

Carrie Hritz, Washington University, St. Louis (previously Research Associate/Post-doctoral fellow)  
 Jason Ur, Harvard University  
 Magnus Widell, The Oriental Institute, University of Chicago (previously Research Associate/Post-doctoral fellow)

**Model Developments (with John Christiansen)**

Much of the programming this past year was devoted to the model framework for social and economic structure. MASS is well along in the development of a prototype modeling approach for automatically synthesizing regional-scale ground movement networks and surface cover patchworks (including settlement field mosaics) from digital maps of settlement layouts, elevations, watercourses, and agricultural land partitions. With the modeling of larger settlements and settlement clusters, considerable attention has also been given to the emergence of ruling elites, leadership contention and succession, distribution of temple resources, and the onset and perpetu-

ation of social stratification — including the establishment of patron-client relationships among households. Nomads and exchange networks incorporating agents outside the settlement continue to be integral features of the model. Other research has focused on climate stress.

### **Northern Mesopotamia**

Much of the work in the north has been devoted to regional analysis of settlement clusters; now, the basic framework for a system of some thirty settlements is in place. The MASS team is designing improved context-sensitive mechanisms for efficiently distributing the computational load for the heterogeneous, multi-model simulations across the nodes of a processor cluster/network. With this, the MASS team has also developed a ground-movement model for both internal, socioecological, process representation and animation graphics to display the flow of workers and materiel through and among villages and to and from work sites. Future work in this area includes the possibility of incorporating “Shulgi,” a new pedestrian simulator developed by the Center for Ancient Middle Eastern Landscapes of the Oriental Institute, into the model.

### **Southern Mesopotamia**

To support agricultural simulations in irrigated southern Mesopotamia, the MASS team has researched and constructed a comprehensive, fine-scale simulation representation of the dynamics of irrigated agriculture. This was a major challenge, including, as it did, the requirement to represent strongly interlinked cultivation and irrigation activities and water balance processes in the same landscape partitions (e.g., crop fields). As a critical part of this activity, members of Argonne designed and implemented enhancements to the USDA’s SWAT model to accommodate the increased complexity and subtlety of irrigation management operations. Later elements to be incorporated into the southern model include date cultivation and fishing.

### **Education, Outreach, and Other Developments (with John Christiansen and Tony Wilkinson)**

Several efforts were devoted to educational outreach and related developments this past year. At the initiative of M. Altaweel, the team introduced a possible curriculum for teaching modeling methods (e.g., system dynamics, agent-based and process-oriented modeling, etc.) to a larger audience. This is currently being developed at Argonne and will include a toolkit for model-building similar to those toolkits already available in other contexts. Along these lines, the team is also looking at the possibility of making the model freely available with open-source software.

In October 2007, MASS members based at Argonne participated in the Argonne Open House, an all-day event open to the general public and attended by over 18,000 people. MASS members continuously ran simulations with projected animation displays and discussed both the NSF-supported ancient Mesopotamian project and a recent spin-off pilot project that focuses on modern Southeast Asian micro-agroeconomics. The MASS Bronze Age simulation project and its modern-day Southeast Asian spin-off project were later featured in Argonne’s “Introduce a Girl to Engineering Day,” February 22, 2007. There, MASS members demonstrated and described this work and engaged in spirited discussions with groups of middle school girls and their schools’ faculty mentors. At both events, the MASS work was selected as one of a handful of research efforts upon which to direct the public’s attention, from among the hundreds of diverse and worthy ongoing R&D activities at Argonne. Along with this outreach, MASS has spawned several projects through the University of Chicago/Argonne National Laboratory Joint Theory Institute, including more refined simulations of specific issues such as human movement and the formation

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and evolution of language. Through these related projects, the MASS model itself grows more refined.

During his tenure as PI, Tony Wilkinson was particularly active in communicating MASS work to other researchers within the field of social modeling and in promoting general outreach activities to inform fellow academics about the advantages of modeling complex systems. He was awarded \$2,800 to organize a seminar on “Modeling Behavior” at Durham University, with an additional £1,000 (\$1,900) made available for a lecture series on the subject of “Modeling Being Human” to follow in 2008 (with Professor Michael Goldstein; Durham, Dept. of Mathematics). Through Professor Wilkinson’s efforts, MASS representatives have participated in sessions on modeling complex systems organized by Doug White (Oxford), Tim Kohler (Santa Fe Institute and the Society for American Archaeology), and others. More general communications are being presented at meetings such as the Theoretical Archaeology Group conference, (Exeter, UK), the Hewlett Packard Centre’s eGrid Seminars (Birmingham, UK) and at the University of Durham Institute of Advanced Studies (the last named has as its theme “Modeling,” for 2007/2008).

The list of talks and publications given by individual members of the MASS team is far too lengthy to present in full here. Two noteworthy publications, representing collaborations by several team members, appeared this past year: “Modeling Settlement Systems in a Dynamic Environment: Case Studies from Mesopotamia” (in *The Model-Based Archaeology of Socionatural Systems*, edited by T. A. Kohler and S. E. van der Leeuw, pp. 175–208 [Santa Fe: School for Advanced Research Press]) and “Urbanization within a Dynamic Environment: Modeling Bronze Age Communities in Upper Mesopotamia” (*American Anthropologist* 109: 52–68).

### Work for the Coming Year

In 2007/2008 the MASS project enters its final year under the present NSF grant. The team has begun initial planning for a MASS symposium to be held at the Oriental Institute in January 2008 (immediately following the annual meeting of the American Institute of Archaeology, which takes place in Chicago next year). A draft of the final monograph will be presented to the University of Chicago Press by August 2008.

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